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April 4, 2006
G-1241-YNG-087

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Hand Delivered

Mr. Dean Yasuda
Environmental Engineer
Department of Ecology, NW Regional Office
3190 160th Avenue S.E.
Bellevue, Washington 98008-5452

Dear Mr. Yasuda:

BOEING

Subject: Boeing Everett Facility - Powder Mill Gulch Draft Source Area IAWP

I have enclosed two copies of the following document:

- Draft Source Area Interim Action Work Plan, Powder Mill Gulch, Boeing Everett Plant, Washington, prepared by Landau Associates, dated April 4, 2006

If you have any questions, please call the undersigned.

Sincerely,

Y. Nicholas Garson, P.G.
Project Manager
Boeing SSG Environmental Remediation
Cell Phone 425-269-7866

CC:

Ben Farrell	Tetra Tech, EM
David Tyler	City of Everett

Central Files Copy

Boeing Everett
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Draft
Source Area Interim Action Work Plan
Powder Mill Gulch
Boeing Everett Plant, Washington

April 4, 2006

Prepared for

The Boeing Company

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1.0 INTRODUCTION

This document constitutes the work plan to conduct an interim action (IA) to remediate the trichloroethene (TCE) source zone present in Powder Mill Gulch (Site) at the Boeing Commercial Airplanes (BCA) Plant in Everett, Washington (Everett plant). The IA consists of treating the groundwater aquifer in the source zone through *in situ* Electrical Resistance Heating (ERH) with contingency treatment by enhanced *in situ* biodegradation. ERH involves heating the source zone aquifer to boil off aqueous-phase and sorbed-phase volatile organic compounds (VOCs), and collection and treatment of VOC-laden soil vapors. This work plan provides the IA design and describes system construction, startup, operation, and monitoring. The IA will be conducted under Agreed Order No. DE96HS-N274 (Order) and subsequent amendments between The Boeing Company and the Washington State Department of Ecology (Ecology). The site location is presented on Figure 1.

Landau Associates and its subcontractor, Thermal Remediation Services (TRS), will share responsibility for implementation of the IA. TRS is responsible for system design; their design plans and specifications are included in Appendices B and C of this work plan. Landau Associates and TRS will both oversee system installation, with Landau Associates and other subcontractors primarily responsible for installation of aboveground piping and below grade components (e.g., wells and electrodes), and TRS responsible for electrical connections. TRS will be responsible for system startup, operation, and system monitoring. Landau Associates will monitor groundwater (baseline, performance, and post-treatment monitoring) and system effluent (treated vapors and condensate) and will be responsible for effluent treatment. Work will be performed in accordance with the Landau Associates and Thermal Remediation Services (TRS) health and safety plans for the site (Landau Associates 2005, TRS - In Preparation). Project responsibilities are further detailed in the TRS project proposal (TRS 2006).

This work plan is prepared under the assumption that the reader is familiar with the site and related work plans and reports. Therefore, details regarding site background, site history, and physical characteristics presented in previous reports and in Section 21 of the draft Remedial Investigation (RI) report (URS 2005a) are not repeated. Pertinent sections of the Quality Assurance Project Plan (QAPP) Revision 1.4 (URS 2005b) and the sampling and analysis plan (SAP) for remedial investigation (Dames & Moore 1997) are adopted by reference. Of particular relevance to this work plan are those sections of the QA/QC Plan and SAP covering monitoring well installation, design, and development; field documentation; decontamination procedures; sampling and analysis procedures; and chain-of-custody protocol.

2.0 BACKGROUND

TCE in the Powder Mill Gulch drainage basin was first detected in surface water samples collected from Powder Mill Creek in 1998 and 1999 as part of the facility RI. These samples were collected at a point located approximately 600 ft downstream of the detention basin that receives stormwater runoff from the Everett plant. TCE was not detected at that time in stormwater discharging from the detention basin, nor was there any record of TCE usage in the area of the detention basin or of a TCE spill to the stormwater drainage system at the Everett Plant. TCE was first detected in Powder Mill Gulch groundwater in March 2003 with the installation and sampling of monitoring well EGW075. A phased RI continued through February 2006 to characterize the nature and extent of the groundwater plume and discharge of contaminated groundwater to surface water in Powder Mill Creek (URS and Landau Associates - In Preparation).

Based on site characterization activities in and around the detention basin, the TCE source zone is limited to the shallow aquifer below the deepest portion of the basin near the basin outlet. Groundwater concentrations of TCE are highest near the outlet and decrease radially in all directions.

The TCE groundwater plume in Powder Mill Gulch extends northward from the stormwater detention basin, beneath Seaway Blvd., and ultimately discharges at points along Powder Mill Creek approximately 1,000 ft north of Seaway Blvd. The plume, defined by TCE concentrations in groundwater greater than 5 μg/L, is approximately 2,850 ft in length. TCE was recently measured in groundwater at concentrations as high as 31,000 μg/L in the source zone, 2,000 μg/L at Seaway Blvd, and 860 μg/L near the leading edge of the plume at the northern extent of the shallow aquifer. Low levels of TCE breakdown products cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride (VC) are also present throughout much of the plume. The plume has been characterized by groundwater samples, seep samples, and surface water samples. The TCE plume and investigation locations are presented on Figure 2.

The plume is present primarily in the upper portion of the Esperance Sand aquifer, at depths of 4 to 75 ft below ground surface (BGS). A 4-ft thick silt layer within the Esperance Sand is relatively continuous over the length of the plume and serves as a barrier to deeper vertical migration of TCE in the source zone and over most of the downgradient dissolved-phase plume. North of Seaway Blvd and near the leading edge of the plume, contamination is observed below the 4-ft silt layer, where the silt is shallow and a sanitary sewer pipeline and the bed of Powder Mill Creek has cut through it. Contamination below the 4-ft silt layer has not been found to extend to the Lawton Clay unit, present approximately 30 ft below the silt layer.

The source zone beneath the basin is largely characterized by samples from borings in the bottom of the basin, and monitoring wells adjacent to the basin and on the inside slope of the basin embankment.

Soil vapor samples and depth-discrete groundwater samples were collected from borings in the basin; groundwater was sampled to a maximum depth of 40 ft below basin bottom (BBB) using direct-push drilling techniques. Due to dense aquifer conditions that prevented deeper direct-push drilling and tight aquifer soils that prevented groundwater sample recovery from some intervals, the aquifer interval between 40 ft and 71 ft BBB (top of 4-ft silt) is largely uncharacterized. However, TCE and breakdown products were not detected in two downgradient wells (EGW100 and EGW130) that are screened just above the 4-ft thick silt layer, suggesting that contamination may not extend to the silt. The groundwater flow direction is to the northeast and groundwater results for a deep monitoring well located immediately downgradient of the source zone (EGW091) indicates that TCE contamination does not extend below the 4-ft thick silt layer. Soil vapor and groundwater concentrations of TCE and breakdown products are presented on Figure 3.

Soil vapor concentrations detected below the basin are consistent with soil vapor concentrations resulting from volatilization of TCE from groundwater and do not indicate a significant vadose zone source of TCE. This interpretation is based on studies presented in Pankow and Cherry (1996) and Rivett (1995) that presented soil vapor concentrations around an emplaced source of TCE DNAPL located in the vadose zone and above an emplaced source of TCE DNAPL located below the water table. In these studies, TCE concentrations in soil vapor measured within 20 ft of the vadose zone emplaced source ranged from approximately 100 to 30,000 µg/L. By contrast, TCE concentrations in soil vapor ranged from approximately 0.1 to 1 µg/L within a similar distance of the emplaced source located below the water table. As shown on Figure 3, TCE concentrations in soil vapor samples collected from within the Powder Mill Gulch source area beneath the detention basin ranged from less than 0.05 to 0.54 µg/L. The Powder Mill Gulch range of concentrations is the same as was reported by Rivett and Pankow and Cherry for the emplaced TCE source located below the water table, and 2 to almost 5 orders of magnitude less than the concentrations they reported for the vadose zone emplaced source. The limited mass of TCE measured in the vadose zone below the detention basin may indicate that the release is old and that most of the TCE mass that may have been present in the vadose zone has volatilized and/or that nearly all of the TCE mass reached the aquifer.

Due to the impracticality of performing additional drilling within the basin during the wet months prior to the start of interim action construction, the vertical extent of the required treatment zone will be further refined as a first step in the interim action. A design investigation will be performed to determine the required depth of treatment prior to drilling for installation of electrodes and other remediation system components as described in Section 7.2.

3.0 SOURCE AREA INTERIM ACTION OBJECTIVE

In general terms, the objective of the IA is to reduce the remediation timeframe for the dissolved-phase groundwater plume through destruction of TCE mass in the source zone. The presence of a DNAPL source zone provides a continuous, long-term source for the downgradient dissolved-phase plume, resulting in remediation timeframes of several decades or longer where pump and treat, or other containment technologies, are applied without source zone treatment (Lowe et al. 1999). Destruction of chlorinated ethene mass in the source zone (i.e., source zone depletion) is commonly implemented as part of the overall remediation strategy for a dissolved-phase plume. Treatment of continuing sources is required for implementation of monitored natural attenuation (MNA) (Ecology 2005; EPA 1999). Source zone treatment results in reductions in source longevity, mass flux from the source zone to the down gradient plume, and long-term risk, as compared to remedial strategies that rely solely on long-term plume management or containment (Christ et al. 2005). Reduction of the overall remediation timeframe resulting from source zone treatment may also reduce life-cycle remediation costs (EPA 2004, 2003; ITRC 2005; Moretti 2005).

It should be understood that source zone treatment is unlikely to reduce source zone groundwater concentrations to Federal Maximum Contaminant Levels (MCLs) within a reasonable timeframe. In fact, reduction of DNAPL source zone concentrations to MCLs has not been documented at any known sites and achieving MCLs in a source zone is considered beyond the capabilities of currently available *in situ* treatment technologies in most geologic settings (EPA 2003). However, aggressive source zone treatment has successfully reduced chlorinated ethene concentrations to levels appropriate for implementation of MNA and achievement of remedial action objectives (RAOs) for downgradient plumes (EPA 2003, Christ et al. 2005). At least seven DNAPL sites have achieved regulatory closure, in spite of residual concentrations above MCLs, through application of risk-based cleanup levels and cleanup criteria specific to land use (e.g., commercial, industrial; EPA 2004). This reflects a recent trend toward flexible regulatory approaches that do not impose non-degradation requirements or MCLs in source zones, but view partial depletion of source zones as an intermediate goal for phased site cleanup (EPA 2003).

Specifically, the remedial action objective (RAO) of the IA is to reduce TCE concentrations to less than 500 µg/L at all monitoring points within the ERH treatment area and at downgradient wells EGW088 and EGW144. The 500 µg/L cleanup goal is based on the anticipated performance of ERH in treating the source area and the presence of higher concentrations of TCE in the downgradient plume. As indicated in Section 2.0, TCE concentrations in the downgradient plume are as high as 2,000 µg/L; therefore, it would be inefficient to target a very low cleanup level in the source zone (e.g., MCL) while significantly higher concentrations remained in the downgradient plume. The ERH treatment area is defined as the area within and approximately 10 ft beyond the electrode array where the aquifer will be heated to the boiling point of TCE (Section 6.2.1). Enhanced biotic and abiotic degradation of TCE is expected to occur within and outside of the active treatment area due to increased aquifer temperature; degradation mechanisms are described in Section 5.3. Current TCE concentrations at downgradient wells EGW088 (1,300 μg/L) and EGW144 (630 μg/L) are expected to decrease due to mass destruction in the ERH treatment zone and due to treatment at those downgradient wells resulting from enhanced biotic and abiotic degradation of TCE. TCE concentrations are currently less than 500 μg/L at other monitoring wells adjacent to the active treatment area (EGW078, EGW091, EGW100, EGW129, and EGW130). Performance groundwater monitoring will be conducted as described in Section 9.0. Contingency measures that may be implemented to achieve the RAO are described in Section 11.0.

4.0 TECHNOLOGY SELECTION

A number of technologies were considered for *in situ* treatment of TCE and breakdown products present in the source zone aquifer, including thermal treatment, enhanced biodegradation, chemical oxidation, and co-solvent flushing. Two technologies, chemical oxidation and co-solvent flushing, were screened out following initial consideration. Chemical oxidation is not considered a good choice given the observed silty and heterogeneous conditions of the source zone aquifer, which would likely result in incomplete delivery of chemical oxidant to the source zone contaminant mass.

Co-solvent flushing is not applicable, as it is typically used in source zones with significant DNAPL. Soil vapor and groundwater concentrations in the Powder Mill Gulch source zone do not indicate significant DNAPL mass.

Enhanced biodegradation and ERH were given further consideration. The enhanced biodegradation approach requires injection of electron donor substrates (e.g. sodium lactate, vegetable oil) into the aquifer to stimulate anaerobic reductive dechlorination. Evidence of low hydraulic conductivity and heterogeneity in the source zone aquifer, and associated uncertainty regarding the effective delivery and distribution of electron donor substrates required for enhanced biodegradation, resulted in selection of ERH as the primary technology for the IA. During the source zone investigation conducted in September 2005, it was observed that groundwater samples could not be obtained from some intervals of borings within the north end of the basin where the highest concentrations of TCE were detected due to very low aquifer hydraulic conductivities. This low aquifer recharge suggests localized silty conditions in the zone of greatest contamination. Flow rates measured during subsequent injection tests at wells EGW127 (<1 gpm) and EGW128 (17 gpm) confirmed the low hydraulic conductance of the source zone. Injection test results and a large variation in aquifer recovery rates observed during groundwater sampling in the basin also indicated significant heterogeneity in and around the aquifer source zone targeted for treatment. By contrast, ERH is a highly effective approach for treatment of low conductivity and highly heterogeneous aquifers, as described in Section 5.0. ERH is also a much more rapid source zone remediation method with most applications achieving cleanup objectives in less than one year. Enhanced biodegradation is planned as a contingent measure, if needed, following source zone treatment with ERH (Section 11.0).

5.0 ERH DESCRIPTION

ERH involves electrical heating of the aquifer to boil off aqueous-phase and sorbed-phase contaminants, collection of contaminant vapors in the vadose zone, and treatment of the vapors. ERH is typically applied in source zone areas where high contaminant concentrations result in a favorable ratio of mass removed per unit of energy consumed. ERH is not typically used for treatment of large dissolved-phase plumes. ERH has been applied in more than 40 full-scale source zone treatments (Beyke 2006). Much of the following technology description is taken directly from a recent article published in the Remediation Journal (Beyke and Fleming 2005).

5.1 HISTORY

ERH was developed at the Pacific Northwest National Laboratory (PNNL) in the early 1990's with funding provided by the U.S. Department of Energy's (DOE's) Office of Science and Technology. The technology was originally conceived as a dewatering tool for the PNNL's *in situ* vitrification process. It was later discovered that ERH was well suited for the *in situ* thermal remediation of volatile contaminants and petroleum hydrocarbons. In aquifer remediation applications, the subsurface is heated to the boiling temperature of water and steam is generated *in situ*; however, only a small portion of the groundwater or soil moisture is boiled off during the remediation.

ERH became commercially available for use as a stand-alone technology in 1997. ERH can be applied using three or six phases of electricity; three-phase heating is generally more applicable for full-scale treatment and six-phase heating is generally more applicable to the pilot scale. Because pilot applications were more common in the early years, the term "six-phase" heating became almost synonymous with ERH. Full-scale heating applications are more common today, and the more general term "electrical resistance heating" is now used to describe the remediation technique, regardless of whether three or six electrical phases are used.

5.2 PROCESS

The ERH process heats the aquifer to boil off aqueous-phase and sorbed-phase contamination, collects steam and contaminant vapors by a soil vapor extraction system, and treats the vapors prior to discharge. An electrical current is passed through the soil and groundwater between electrodes in the area requiring treatment. Resistance to the flow of electrical current heats the soil and boils the target contaminant and a portion of the soil moisture into steam. Steam serves as a carrier gas to sweep VOCs to vapor recovery (VR) wells. After the steam is condensed and the extracted air is cooled to ambient temperature, the VOC vapors are treated using conventional methods, including granular activated carbon (GAC) or oxidation.

5.2.1 HEATING

Electrodes are usually placed in the subsurface throughout the remediation area using standard drilling techniques. An electrode is a well with the added capability of directing electrical current to the proper depth for subsurface heating. Occasionally, electrodes may be installed by direct-push methods or pile driving. The depth at which electrodes may be placed at a given site is dependent upon the depth to which drilling can be accomplished and the vertical extent of contamination. The electrodes also serve as vapor- and steam-recovery points, or can operate as multiphase extraction wells for the recovery of vapor, steam, water, and non-aqueous phase liquid (NAPL) from the subsurface.

The horizontal spacing between electrodes is usually 14 to 24 ft. The optimal electrode spacing is not typically influenced by soil type, water saturation, or the electrical conductivity of the subsurface, but by overall project costs. Closer-spaced electrodes lead to higher installation costs, but allow faster heat input and less operating time. Conversely, wider-spaced electrodes result in lower installation costs, but require a longer and more expensive operating period.

A power control unit (PCU) is used to direct conventional three-phase electricity from municipal power lines to the electrode field through insulated cables. The electrodes conduct alternating current (AC) into the subsurface and are specifically designed to input energy at targeted depth intervals. Electricity may be directed to groups of electrodes, or electrode intervals, either simultaneously or sequentially depending on the size of the volume being treated, or the desired heating pattern. PCUs of varying size are used to deliver, control, and monitor the electricity applied to the subsurface during ERH operations.

The PCU control computer is used to both monitor and control site activities and may be accessed directly or remotely. Subsurface temperatures are monitored throughout operations using temperature monitoring points (TMPs) containing thermo-couples at 5-foot subsurface intervals. Temperature, voltage, vacuum, airflow, and subsurface pressure data are collected on set schedules and uploaded daily to the PCU control computer.

The electrodes, which are in electrical contact but out of phase with each other, pass the electrical current through the aquifer or vadose zone materials between them. Moisture present in the vadose and saturated zones conducts the electricity in the target treatment interval. The natural resistance of subsurface materials to the flow of electrical current results in heating of the treatment area.

Portions of the subsurface with higher electrical conductivity, such as low-permeability lenses or stringers of silt or clay, and areas contaminated with chlorinated solvents, are heated preferentially. Silts and clays are naturally more conductive than sands and gravels. Chloride ions present in groundwater around areas where chlorinated solvents are undergoing reductive dechlorination also create areas of higher conductivity. Preferential heating of fine-grained aquifer materials is especially important in the remediation of chlorinated solvents, which are often bound to low-permeability silts and clays, making them difficult to remediate by other technologies.

5.2.2 COLLECTION AND TREATMENT

The production of steam during ERH operations effectively provides a mechanism for *in situ* steam stripping of VOCs from both soil and groundwater. *In situ* steaming serves two purposes: 1) the physical action of steam production drives contaminants out of soil, overcoming low-permeability and capillary forces, and 2) the steam acts as a carrier gas to transport contaminants toward the water table and into the VR wells co-located with the electrodes. As described by Raoult's Law, the presence of oil, grease, or other low-volatility hydrocarbons can slow the evaporation rate of VOCs, making steam stripping a very important treatment mechanism where these contaminants are co-mingled.

Aboveground, the steam is condensed to water and vapors are cooled to near-ambient temperatures. As described by Henry's Law, less than 1 percent of the VOCs collected from the subsurface will condense and become dissolved in the condensate. Collected VOCs remain part of the vapor stream and are treated by conventional vapor-abatement technologies such as thermal and catalytic oxidation or granular activated carbon (GAC). GAC will be used for the Powder Mill Gulch source zone application.

5.3 TREATMENT PROCESSES

Although volatilization is usually the primary VOC removal mechanism during ERH, a significant fraction of the VOCs will be degraded in place by natural *in situ* processes that are stimulated by increased temperature, including biodegradation, hydrolysis, and reductive dehalogenation by zero-valent iron. It may take up to a year for aquifer temperatures to return to baseline temperatures following ERH. Elevated temperatures increase the rates of abiotic reactions (hydrolysis and dehalogenation) in accordance with the Arrhenius Equation, which indicates that reaction rates increase by a factor of about 2.5 for each 10°C increase in temperature. Biotic processes are also enhanced at elevated temperatures. Data suggests that mass destroyed *in situ* is nearly equal to the mass removed by soil vapor extraction for *ex situ* treatment. These treatment processes are described in greater detail below.

5.3.1 VOLATILIZATION

Once subsurface heating starts, the boiling points of various VOC/water mixtures are reached in the following order: separate-phase NAPL in contact with water or soil moisture, followed by dissolved VOCs, and, finally, uncontaminated groundwater. This order of volatilization results from Dalton's Law of Partial Pressures, which describes how a VOC/water mixture will boil when the vapor pressure of the VOC plus the vapor pressure of water is equal to the ambient pressure. Consequently, the boiling point of a VOC immersed in water or in contact with moist soil, is depressed below the individual boiling points for water or the VOC. The individual boiling points for TCE and water in air at standard pressure are 87 °C and 100 °C, respectively; the combined boiling point for TCE in water is depressed to 73 °C. This order of volatilization is obviously advantageous for ERH remediation as contaminated water will tend to boil off before uncontaminated water, reducing the time and energy required to complete treatment.

5.3.2 BIODEGRADATION

Elevated temperatures in the range of 50 to 60°C appear to be ideal for dechlorinating microbes and temperatures of about 35°C appear to be ideal for the dehalococcoides bacteria responsible for reductive dechlorination of cis-1,2-DCE to VC. Aquifer temperatures will be much higher during active heating (approximately 120°C). This high temperature appears to reduce the activity of bacteria, but does not sterilize the aquifer. Data from other sites show rapid reestablishment of bacteria, including dechlorinators, following active heating (Beyke 2006). *In situ* biodegradation is most significant at sites where relatively high levels of naturally occurring total organic carbon (TOC) or nonchlorinated hydrocarbons provide a source of electron donor. The aquifer may also be amended with electron donor substrates following active heating to facilitate this process.

5.3.3 HYDROLYSIS

Hydrolysis is a water-substitution reaction in which hydrogen ions normally present in water react with organic molecules, replacing chlorine atoms. Oxidizing conditions or available oxygen is not required for hydrolysis. Hydrolysis can be a significant degrader of some VOCs at room temperature, especially halogenated alkanes. The hydrolysis rates of alkenes, including TCE, are very slow and do not constitute a significant degradation mechanism (Beyke 2006).

5.3.4 DEHALOGENATION

The backfill of ERH electrodes include steel shot, which is a form of zero-valent iron. The reductive dehalogenation process that takes place at the electrode backfill is the same as that produced by iron-filing permeable reactive barriers. The presence of iron in the electrode boreholes can provide a significant polishing mechanism for dissolved-phase VOCs after heating has ended.

6.0 ERH DESIGN

The ERH system is designed to treat the aquifer zone extending from the water table to a depth of 45 to 70 ft BBB over the area where TCE has been detected in groundwater at concentrations of 3,000 µg/L or greater. The actual depth of treatment will be determined by the results of the design investigation (Section 7.2). Active source zone treatment (i.e. heating) will target the saturated zone only, due to the low soil vapor concentrations that are not indicative of a significant vadose zone source (Section 2.0). However, vapor recovery performed in conjunction with heating will also remove VOC mass currently present in the vadose zone. System design drawings are presented in Appendix A and specifications are presented in Appendix B.

6.1 TREATMENT ZONE

Given the current uncertainty regarding the depth of contamination, the system is designed for three possible treatment depths over the treatment area. Treatment depth will influence the length of electrodes, treatment time, remediation energy, and the VOC mass removed and treated. This work plan provides a flexible system design to treat to depths of 45 ft, 55 ft, or to the silt at 70 ft BBB. Depending on the results of the design investigation, the treatment depth can also be adjusted between these three design depths, as appropriate. The 14,000 ft^2 area of treatment will be the same regardless of treatment depth.

Heating will be conducted primarily on that portion of the aquifer with TCE groundwater concentrations of 3,000 µg/L or greater. However, on the upgradient (south) edge of the source zone, treatment will also be extended to portions of the aquifer where TCE concentrations are less than 3,000 µg/L to prevent inflow of contaminated groundwater to the treatment zone that might prevent achievement of the RAO. The ERH treatment area is approximately 14,000 ft^2, as presented on Figure 4.

6.2 SYSTEM DESCRIPTION

The ERH remediation system consists of components for aquifer heating, vapor and steam collection, treatment of vapor and condensate, monitoring, and remote operation. Health and safety features of the system are also described. The layout of system components is presented on the plot plan (No. EVE06-PP-01) of Appendix A. The system process diagram is presented on the process flow diagram (No. EVE06-PFD-01).

6.2.1 HEATING

Aquifer heating will be accomplished with electrodes connected to a 2,000 kilowatt (kW) power control unit (PCU). Depending on the required depth of treatment (45 to 70 ft BBB), it is estimated that 2.4 to 4.4 million kilowatt hours (kW-hr) will be delivered to the electrode array to achieve the RAO. Electrode locations are shown on Figure 4.

Electrodes are composed of 2-inch diameter, Schedule 40 steel pipe constructed with conductive backfill in a 12-inch diameter boring. The steel pipe is slotted across the saturated zone and into the vadose zone. Vadose zone slots compose the vapor recovery wells at each electrode. Electrode slots across the saturated zone allow contingent injection of electron donor substrates (Section 11.0). Each electrode consists of two conductive intervals across the treatment depth to allow targeted heating. Conductive intervals are separated from each other by non-conductive thermal plastic fittings. Non-conductive casing is also located above the upper conductive interval to prevent current from being transmitted to the surface. In conductive intervals, backfill around the electrode consists of an electrically conductive mixture of steel shot and graphite. Non-conductive intervals between conductive zones and in the vadose zone will be backfilled with non-conductive 8/10 sand. Each electrode/VR well will be constructed with a surface seal composed of 5 ft of neat cement grout and 2 inches of two-part epoxy. Detailed electrode design for the three design depths is presented on the electrode detail (No. EVE06-ED, 1 of 5) in Appendix A.

Electrode wells will be completed for connection to VR piping, the PCU, and a water drip system. Each electrode well will be completed with a flanged tee, with the horizontal leg connected to the VR piping and the vertical leg sealed with a blind flange for potential future access. Each electrode will be connected to the PCU by a 4-gauge, type W insulated cable (mining cable). A drip tube of 0.5-inch diameter cross-linked polyethylene (PEX) tubing will pass through a compression fitting in the blind flange to allow rewetting of electrodes, as needed. PEX tubing will extend to the equipment compound and will be manually connected to the potable water source, or to treated condensate, as needed. The volume of steam condensate removed from the source area and the volume of any added drip water will be monitored so that the volume of drip water remains less than the volume of groundwater removed as steam. This net removal of groundwater will result in an inward hydraulic gradient and hydraulic control of the treatment area. These features are presented in the piping and electrode detail (No. EVE06-ED, 4 of 5). The PEX tubing stand in the equipment compound is presented in the PEX detail (No. EVE06 VR DETAIL, 2 of 2).

6.2.2 Vapor and Steam Collection

VR piping will extend from each electrode well to a 40-hp vacuum blower for collection of steam and vapors. All pipe and fittings 6 inches in diameter or smaller will be of Schedule 80 chlorinated polyvinyl chloride (CPVC) pipe; 8-inch diameter pipe and fittings will be Schedule 40. Schedule 40 pipe is used for the 8-inch diameter piping, as it is used at higher elevations where potential submergence pressures are less than for the smaller diameter piping. CPVC fittings will be solvent welded. The VR pipe connected to each well will be 1.5 inch in diameter. Piping will be manifolded together above the normal 8-ft water level in the basin. Individual pipes for wells located below the 8-ft water line will extend along the bottom of the basin and up the embankment slope to manifolds above the 8-ft water level. Piping will pass through anchored pipe sleeves to counteract buoyancy while allowing expansion and contraction of the piping. Piping manifolds will include ball valves for flow adjustment and isolation of each VR well. The PEX drip tube extending from each well head will also be utilized for remote vacuum measurements at each individual well to balance the vapor recovery system. VR manifold design is presented on the vapor recovery detail (No. EVE06 VR DETAIL, 1 of 1) in Appendix A. Pipe anchoring and the PEX drip tube are shown on piping and electrode detail (No. EVE06-ED, 4 of 5).

The vapor recovery system is designed to produce detectable vacuum 10 ft beyond the ERH treatment area (i.e., beyond the aquifer zone heated to boiling point of TCE in water, 73 °C). Subsurface vacuum will be measured at four vadose zone vacuum monitoring wells located 10 ft beyond the active treatment area (i.e., 19 ft from the nearest line of electrodes) (Figure 4). Detectable vacuum will be confirmed at these locations prior to active heating, as described in Section 7.4. A temperature sensor, at 20 ft BBB (5 ft below the water table), will be co-located with each vadose zone vacuum monitoring well to confirm the aquifer temperatures at those locations. Vacuum monitoring points will be of similar construction to groundwater monitoring points with co-located temperature monitoring points (TMPs) (Section 6.2.4.2). Vacuum monitoring well design is presented on the vacuum monitoring well detail (No. EVE06-ED, 3 of 5) in Appendix A.

6.2.3 Treatment of Vapor and Condensate

Collected steam and vapor will pass through a condenser, generating separate condensate and VOC vapor streams that will be treated prior to discharge or reuse (condensate). Following the condenser, VOC vapors will pass through vapor-phase GAC vessels for treatment then be discharged to the atmosphere. Four 1,000-lb GAC vessels will be utilized for vapor treatment; two redundant groups of parallel GAC vessels will be located in series. Liquid-phase GAC will be used to treat the condensate; two drums of liquid-phase GAC in series will be used for treatment. Treated condensate will be reused as cooling water for the condenser and as drip water for electrodes, as needed. Excess treated condensate, if any, will be discharged to the sanitary sewer. It is anticipated that 6,000 to 13,000 lbs of vapor-phase GAC and up to 250 lbs of liquid-phase GAC may be required for vapor and condensate treatment, respectively. Effluent monitoring will be performed to determine the time of GAC replacement, as described in Section 6.2.4.1. This treatment train is shown on the process flow diagram (No. EVE06 PFD 01) of Appendix A.

6.2.4 MONITORING

Monitoring will be comprised of system monitoring and performance monitoring of groundwater. System monitoring is performed for optimization of the ERH system. Performance monitoring will consist of groundwater sampling within the treatment zone to evaluate progress toward the RAO.

6.2.4.1 System Monitoring

System monitoring will consist of real time remote monitoring and weekly site visits. TRS will monitor system operation and treatment zone temperature remotely by telephone service. Temperature data will be automatically recorded at least once per day from 10 TMPs co-located with groundwater monitoring wells. Each TMP will be constructed of 1-inch diameter Schedule 40 stainless-steel pipe or fiberglass reinforce epoxy (FGRE) well casing containing one temperature sensor per five vertical feet of treatment zone. Condenser inlet and outlet temperatures, and VR outlet temperatures are automatically recorded. TRS will visit the site weekly to every other week for visual inspection and maintenance of the electrical components of the system. Landau Associates will visit the site one to two times per week to monitor, and perform any needed maintenance on, the VR and effluent treatment systems. Additional visits will be made, as necessary, to ensure the ERH system is functioning efficiently and effectively. During site visits, samples of vapor and condensate will be collected for analysis; samples will be collected weekly to twice per month, depending on results. The System Monitoring Plan is provided in Appendix C.

6.2.4.2 Performance Monitoring

A total of 10 groundwater monitoring points, co-located with TMPs, will be installed between the electrodes for performance monitoring of the ERH treatment zone. Groundwater monitoring points will be constructed to allow collection of discrete groundwater samples at 15-ft intervals between the water table and the bottom of the treatment zone. Therefore, each groundwater monitoring point will consist of three or four nested wells, depending on the required depth of treatment that is determined by the design investigation (Section 7.2). Wells will be constructed of 2-inch diameter FGRE well screen (0.020 slot size) and casing. FGRE screen and casing will be composed of 75 percent high silica glass and 25 percent high purity closed molecular epoxy; other fiberglass pipe products contain PVC and will not withstand the elevated temperatures in the treatment zone. Anticipated screened intervals are 20 to 25 ft, 35 to 40 ft, 50 to 55 ft, and 65 to 70 ft BBB with sandpack (2/12 sand) extending 1 ft below and 2 ft above each screen. Each monitoring well cluster will also include a co-located TMP (Section 6.2.4.1). A seal of bentonite pellets will be placed between sandpack intervals and extend from the upper sandpack to within 5 ft of the ground surface. A surface seal composed of 5 ft of neat cement grout and 2 inches of two-part epoxy will be constructed at each groundwater monitoring well/TMP. Groundwater monitoring well/TMP design is presented on the monitoring well detail (No. EV06-ED, 2 of 5) in Appendix A. Performance groundwater monitoring is described in Section 9.0.

A variance will be requested from Ecology's Water Resources program for the nested installation of groundwater monitoring points and TMPs. It is anticipated that the four 2-inch well screens of each monitoring point, and the co-located TMP, will be constructed in a single 12-inch diameter boring drilled with 8.25-inch inside diameter (ID) hollow-stem augers. In order to monitor the aquifer zone centrally between electrodes (i.e., the last point to reach the boiling point of TCE), it is important that monitoring points be constructed in a single boring.

Each groundwater monitoring point within the basin will extend vertically to an elevation that is 10 ft above the bottom of the basin (i.e., to elevation 352) to allow access by boat for groundwater sampling without pumping stormwater from the basin. Monitoring well clusters will be completed in a waterproof protective casing constructed of 8-inch diameter Schedule 40 PVC pipe extending from 4 ft BBB (pipe embedded in the surface seal) to a blind flange at elevation 352 ft. This protective riser extends above the typical height of water in the basin (8.5 ft). All risers longer than 5 ft will be anchored at elevation 347 ft to anchors at ground surface in the basin. Well surface completion is shown on the monitoring well detail (No. EV06-ED, 5 of 5), in Appendix A.

6.2.5 Remote Operation and System Shutdown

The system will be operated remotely by TRS. Based on treatment zone temperature readings, TRS can redirect electrical energy to areas or vertical intervals that may be slower to heat.

The system will shut down automatically in the event of alarm conditions and can also be shut down remotely through the phone line connection. Alarm conditions that will result in system shutdown include high condensate level in the condenser, high or low water level in the cooling tower, or high temperature at the condenser outlet. The system autodialer will notify TRS personnel of any system shutdown that may result from alarm conditions.

6.2.6 Health and Safety Features and Procedures

The ERH system is designed and operated to prevent exposure of personnel and the public to hazardous conditions. The equipment compound will be contained in a fenced compound that will be locked to prevent public access. Electrical and mechanical system components will be contained in weathertight grounded enclosures to prevent inadvertent contact and hazard warning signs will be posted. Electrical and mechanical system components, groundwater monitoring wells, and electrodes will only be accessed following system shutdown and onsite lock out/tag out procedures described in the TRS health and safety plan (TRS - In Preparation). System shutdown and onsite lock out/tag out procedures for groundwater monitoring are also described in the Performance Sampling Procedures (Appendix D). A voltage survey will be performed during system startup (Appendix E, Construction Quality Control Plan) and periodically during system operation to verify that electrical components are adequately grounded and insulated.

6.3 DESIGN CRITERIA, ASSUMPTIONS, AND CALCULATIONS

Much of the design described above is based on TRS proprietary methodology. Design criteria, assumptions, and calculations for three potential depths of treatment are summarized in Table 1.

6.4 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Applicable or Relevant and Appropriate Requirements (ARARs) were evaluated for implementation of ERH in the Powder Mill Gulch source zone. A discussion of ARARs is provided in Appendix F.

7.0 SYSTEM CONSTRUCTION

System construction activities will include pumping stormwater from the detention basin, a design investigation to determine the required depth of treatment, and construction/installation of system components.

7.1 BASIN DEWATERING

To allow for the design investigation and construction activities to be performed in the bottom of the detention basin, the basin will be emptied by pumping stormwater to the sedimentation basin. A 6-inch, 30 horsepower, three-phase, 480 volt, electric submersible pump capable of 1,000 to 1,500 gpm at the required head will be placed near the basin outlet. Stormwater will be pumped through a temporary 6-inch diameter hose and pipe extending along the east side of the detention basin and into the sedimentation basin. It is estimated that this pump will pump the basin down from its normal 8-ft water level (1.3 million gal) in approximately 14 to 21 hrs. The pump will remain in the basin through the end of system construction to allow immediate removal of stormwater that may enter the basin as a result of summer storm events. The pump will be float-switch activated so that it can operate unattended.

Prior to the design investigation and construction activities, any significant thickness of accumulated solids will be removed from the work area. Following the initial pump out of the basin, accumulated solids will be allowed to dry for approximately 1 week and then removed with a loader for proper disposal (Section 10.0).

Boeing currently plans to remove accumulated solids from both the sedimentation basin and detention basin in June 2006. Depending on precipitation and the timing of removal activities, the detention basin may be dry and free of accumulated solids at the beginning of design investigation. In any event, the pump described above would remain in the basin through system construction to allow rapid removal of stormwater that might enter the basin.

7.2 DESIGN INVESTIGATION

A design investigation will be completed immediately prior to system installation to determine the required depth of treatment. The design investigation will include groundwater sampling to estimate the vertical extent of contamination (i.e., groundwater with a TCE concentration greater than 1,000 μg/L) and soil sampling to confirm the depth of the 4-ft thick silt layer in the treatment area.

A single boring will be drilled south of the electrode array with a hollow-stem auger or roto-sonic drill rig to confirm the presence and depth of the 4-ft thick silt unit. The boring will be drilled to 65 ft

BBB without collection of soil samples, followed by continuous soil sampling from 65 ft BBB until the silt layer is encountered. The boring will be located between former temporary wells EGW118 and EGW126. Potable water will need to be added to control heave during soil sampling of the boring, so this boring is located a distance from the groundwater monitoring points described below. The boring is located some distance from the groundwater monitoring points discussed below.

Performance groundwater monitoring points D04, F04, and J04 (Figure 4) will be installed and sampled prior to all other wells. These groundwater monitoring points, and associated TMPs, will be installed immediately adjacent to the three previous direct-push borings in the basin having the highest concentrations of TCE (EGW111, EGW114, and EGW120). Each monitoring point will extend to the silt at 70 ft BBB, with four screened intervals constructed at each sampling point, as described in Sections 6.2.4.2 and 7.3. The monitoring points will be developed and sampled for quick turnaround of VOCs by U.S. Environmental Protection Agency (EPA) Method 8260.

7.3 SYSTEM INSTALLATION

System installation will begin with installation of below-grade components (i.e., system wells) followed by installation and connection of above-grade piping and cables. The depth of electrodes and remaining groundwater monitoring points with co-located TMPs will be based on the results of the design investigation (Section 7.2). The depth of treatment will include areas with groundwater samples containing TCE concentrations of 1,000 µg/L or greater.

System wells will be installed using one or more hollow-stem auger drill rigs. The drill rig(s) will operate on the embankment slope with the assistance of safety cabling connected to a tow truck or other large piece of equipment located at the north toe of the embankment. The locations of all below-grade components will be accurately marked and surveyed for elevation. Hollow-stem augers having an inside diameter (ID) of 8.25 inches [12-inch outside diameter (OD)] will be used for installation of groundwater monitoring points with co-located TMPs. Hollow-stem augers, either 6.25-inch ID (10-inch OD) or 8.25-inch ID (12-inch OD) will be used for installation of electrodes. While installation of electrodes with 8.25-inch augers is preferred, difficult drilling may require the use of 6.25-inch augers, depending on the depth of the treatment zone. Vacuum monitoring points with co-located TMPs will be installed with 6.25-inch ID augers. The details of ERH system wells are presented in Table 2.

Above-grade components within the basin and at the equipment compound will be installed by TRS and a piping contractor. The equipment compound will be constructed and equipment assembled in the compound concurrent with the installation of below-grade components within the basin. Above-grade components within the basin (e.g., piping, cables) will be installed upon completion of all or most of the below-grade components.

Precautions will be taken to prevent leakage of stormwater to the aquifer in the event of a storm that results in stormwater discharge to the basin during construction activities. Below-grade components will be capped with a water-tight seal upon completion and prior to connection to VR piping. Hollow-stem augers that may be left in a partially completed boring overnight or as the basin is evacuated due to a storm event will be sealed with wooden plugs and bentonite chips will be placed around the top of the augers. During construction of VR piping, pipe ends will be capped overnight or if the basin is evacuated due to a storm event. The basin will be evacuated if a storm event occurs with intensity of 0.1 inch per hour or greater, or if inflow to the basin is observed.

Precautions will be taken to prevent distributing contaminated material outside of the basin. The boots and tires of personnel and vehicles operating in the basin will be washed to remove any accumulated sediments prior to leaving the basin. Drill cuttings and well development water will be collected for disposal, as described in Section 11.0.

7.4 CONSTRUCTION QUALITY CONTROL

Construction of the ERH system will be monitored jointly by TRS and Landau Associates. Daily logs will be maintained of construction activities and observations. Component testing (e.g., pressure testing of VR piping, collection of TMP readings) will be performed prior to system startup and refilling of the basin. The VR blower will be operated prior to commencement of heating to measure vacuum at electrodes and at the four vacuum monitoring points. Electrical testing will be performed to confirm current is delivered to each electrode and a voltage survey will confirm that insulative system components are working properly. Quality control activities are detailed further in the Construction Quality Control Plan presented in Appendix E.

8.0 SYSTEM STARTUP AND OPERATION

Once installation is complete, TRS will perform system startup and testing over a period of 1 to 2 weeks. Once testing is complete, power application to the site will be continuous except for system adjustments, routine maintenance, and scheduled performance groundwater sampling events. The system operations and maintenance (O&M) plan is presented in Appendix G.

Depending on the required depth of treatment (45 to 70 ft BBB), it is estimated that 2.5 to 4.4 million kW-hr will be delivered to the electrode array to achieve the RAO. The time required to apply this energy to the subsurface is estimated at 82 to 188 days.

It is anticipated that active heating will be discontinued when TCE concentrations are less than 500 μg/L in all samples from the 10 groundwater monitoring points located within the electrode array. System monitoring and maintenance will be conducted as described in Appendices D and G. Performance groundwater monitoring will be performed to evaluate achievement of the RAO, as described in Sections 6.2.4.2 and 9.0. Contingent measures (Section 11.0) will be applied in the event that the remediation energy is expended prior to achievement of the RAO.

9.0 GROUNDWATER MONITORING

Groundwater monitoring will consist of baseline monitoring, performance monitoring during active treatment, and post-treatment monitoring. As described in Section 3.0, monitoring results from monitoring points within the ERH treatment zone and downgradient wells EGW088 and EGW144 will be used to evaluate achievement of the RAO.

9.1 BASELINE MONITORING

Baseline samples will be collected from each interval of the 10 nested performance monitoring wells (Section 6.2.4.2) and from existing wells adjacent to the treatment area. At least one, and possibly two, groundwater samples will be collected from each interval of the ten performance monitoring wells prior to beginning ERH remediation. The most recent quarterly or semiannual monitoring results will constitute baseline data for adjacent monitoring wells.

9.2 PERFORMANCE MONITORING

Several rounds of groundwater sampling will be performed at the 10 monitoring points inside the ERH treatment area to allow focused treatment and to determine when active heating can be discontinued. It is anticipated that performance monitoring will be performed when treatment is approximately 60 percent, 70 percent, 80 percent, 90 percent, and 100 percent complete, as estimated by TRS. The progress of treatment will be estimated based on various factors, including electrical energy delivered, aquifer temperatures, the time that elevated temperatures have been maintained in the aquifer, and trends in the concentrations of TCE measured in treatment area monitoring points and recovered vapors. Additional performance monitoring will be performed, as needed in addition to regular quarterly monitoring, at downgradient wells EGW088 and EGW144, to evaluate achievement of the RAO.

9.3 POST-TREATMENT MONITORING

Conditions will continue to be monitored following the end of active heating and achievement of the RAO. Post-treatment monitoring will consist of regular quarterly groundwater monitoring, as specified in updated monitoring plans approved by Ecology.

9.4 SAMPLING AND ANALYSIS

Groundwater will be sampled using a non-dedicated submersible pump. It is anticipated that the QED SamplePro stainless-steel bladder pump will be used, due to its easy disassembly for decontamination, the ability to use dedicated sample bladders for each well, and its compatibility to the anticipated temperatures produced by the ERH system. It is anticipated that polypropylene tubing and polyethylene sample bladders will withstand the high groundwater temperatures over the short time period required for sampling. Alternatively, the SamplePro pump may be used with Teflon bladders that have a higher temperature rating, or a Grunfos (Redi-Flow) electric centrifugal pump may be used.

TRS lock out/tag out procedures for electrical safety and procedures for sampling of hot groundwater will be followed during sampling. Prior to groundwater sampling, the system will be shut down remotely followed by a lock out/tag out procedure performed onsite. Procedures for hot groundwater sampling describe cooling of the sample stream to prevent loss of volatiles. These hot groundwater sampling procedures have been approved by various state and federal environmental regulatory agencies in the United States, including the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (USACE) for the Fort Lewis Eastgate Disposal Yard TCE source zone remediation project. Lock out/tag out procedures and hot groundwater sampling are detailed in the Performance Sampling Procedures, presented in Appendix D.

Following system startup and refilling of the stormwater basin, monitoring points that are located below the standard 8-ft water level (elevation 350 ft) will be sampled through elevated monitoring point risers (Section 6.2.4.2). These monitoring wells will be accessed by boat.

Groundwater samples will be analyzed for VOCs by EPA Method 8260 at Analytical Resources Inc (ARI), in Seattle, WA. To provide timely information for remedial decisions, most samples will be submitted on a 24-hr to 72-hr sample turnaround time.

10.0 WASTE MANAGEMENT

Waste will result from system construction, groundwater monitoring, and system operation. Waste will be managed by Boeing in accordance with applicable rules and regulations.

Waste and residuals related to project activities consist of detention basin sediments, drill cuttings, equipment decontamination water, well development water, well purge water, vapor effluent, condensate, and various solid waste. Basin sediments will be dried in the basin then removed for disposal at the Waste Management Inc. Title C landfill in Arlington, Oregon, as polychlorinated biphenyl (PCB) waste. It is estimated that approximately 85 tons of drill cuttings and 800 gal of decontamination water will be generated during system installation. Groundwater monitoring will result in purge water and equipment decontamination water. Water resulting from equipment decontamination, well development, and purging will be managed in accordance with the City of Everett pre-treatment permit. Vapor effluent will be treated with vapor-phase GAC and discharged to the atmosphere (Section 6.2.3). It is estimated that up to 367,000 gallons of condensate may be generated during the project. This condensate will be treated with liquid-phase GAC and used as a make-up water source to the cooling system of the condenser and as a source of drip water to the electrodes (Section 6.2.3.). Any remaining treated condensate will be discharged to the sanitary sewer. Depleted GAC will be returned to the supplier for treatment. Solid waste will include personal protective equipment (PPE) and construction debris.

11.0 CONTINGENCY PLAN

This section describes contingency measures that will be implemented in the event that the RAO to reduce TCE concentrations to less than 500 µg/L within the active treatment area and at downgradient wells EGW088 and EGW144 is not achieved by the end of active heating. TRS is contracted to continue treatment until the desired TCE concentration reduction is observed in all depth intervals of the 10 performance groundwater monitoring points within the ERH treatment zone, or until the design remediation energy has been delivered to the treatment zone. The design remediation energy for each of the three depth-of-treatment scenarios is presented in Table 1. One set of contingent measures will be employed in the event that TCE groundwater concentrations have not been reduced to less than 500 µg/L at all depth intervals of the 10 performance groundwater monitoring points within the treatment zone. A separate contingency measure will be employed if TCE groundwater concentrations are less than 500 µg/L at monitoring points within the treatment zones, but still exceed 500 µg/L at downgradient wells EGW088 and EGW144 at the end of active heating.

11.1 CONTINGENT TREATMENT IN ERH TREATMENT ZONE

Additional treatment will be performed in the event that the design remediation energy has been delivered to the treatment zone, but TCE groundwater concentrations have not been reduced to less than 500 µg/L at all depth intervals of the 10 treatment zone performance groundwater monitoring points. This additional treatment will be accomplished by ERH or by enhanced biodegradation.

Additional treatment by ERH would involve focused delivery of additional electrical energy beyond the design remediation energy to treatment zones where groundwater concentrations remain above 500 µg/L. Treatment would continue until performance groundwater monitoring indicated that TCE concentrations had been reduced to less than 500 µg/L.

Treatment by enhanced biodegradation would involve injection of electron donor substrates (e.g. sodium lactate, vegetable oil) to selected electrode wells to stimulate anaerobic reductive dechlorination in zones where groundwater concentrations remained above 500 µg/L. Prior to implementation of an enhanced biodegradation contingency measure, a tap water injection test would be performed at electrode wells within the target treatment area to evaluate the feasibility of injecting electron donor substrates.

11.2 CONTINGENT DOWNGRADIENT TREATMENT

In the event that TCE groundwater concentrations are less than 500 µg/L at monitoring points within the treatment zone at the end of active heating, but exceed 500 µg/L at downgradient wells

EGW088 and EGW144, a single injection of electron donor substrates will be performed to selected electrodes to stimulate downgradient anaerobic reductive dechlorination, if feasible. The feasibility of injection will be evaluated through injection testing described below. This contingency measure would be employed as a polishing step to treat residual TCE mass present immediately downgradient of the ERH treatment zone.

If feasible, a single injection of electron donor substrates (e.g., sodium lactate, vegetable oil) would be performed soon after the end of active heating to take advantage of the elevated aquifer temperatures that may persist for up to a year following ERH (Section 5.3). Even under elevated aquifer temperatures, significant reductive dechlorination (i.e., biodegradation) is not expected in the Esperance Sand aquifer without addition of electron donor substrates. Very low total TOC concentrations have been detected at source zone wells EGW127 (<1.5 mg/L), EGW128 (<1.5 mg/L), and EGW144 (2.9 mg/L). Groundwater TOC concentrations of less that 10 mg/L are generally considered too low to support reductive dechlorination (Major et al. 2003).

Electrode wells within the three northernmost rows would be evaluated for injection of electron donor substrates. A potable water injection test would be performed at electrode wells within these three rows to evaluate the feasibility of injection. Electron donor injection would be considered infeasible at wells with injection rates of less than 20 gpm.

Up to seven wells would be injected with electron donor substrates. The wells used for injection would be selected based on location and the results of the potable water injection test. Preference would be given to wells located the farthest north (i.e., farthest downgradient) and with the highest injection rate. Wells would also be selected, if possible, to minimize the effective spacing between injection points, as measured perpendicular to the groundwater flow direction.

Approximately 8,000 gal of injection solution comprised of potable water, vegetable oil emulsion, and sodium lactate would be injected to each of the seven electrode wells. It is anticipated that injection solution would contain 3 percent vegetable oil and 2.5 percent sodium lactate by volume. This one time injection of donor substrates is considered adequate to stimulate reductive dechlorination for the period that aquifer temperatures will remain above baseline.

This contingent measure is considered to be an extra step beyond ERH treatment of the highest concentration portion of the source zone and is planned to take advantage of elevated aquifer temperatures for additional mass destruction. No additional treatment is considered in the event that injection is determined to be infeasible or the single injection of electron donor amendment does not result in TCE concentrations less than 500 μg/L at downgradient wells EGW088 and EGW144.

12.0 ERH SYSTEM DECOMMISIONING

Following Ecology review of the final IA report (Section 13.0), the ERH system will be decommissioned. All aboveground system components, including the equipment compound, piping, and cables, will be removed from the site. The equipment compound fencing may remain for future site use. System wells, including electrode/VR wells, vacuum monitoring wells, groundwater monitoring wells, and TMPs, will be abandoned. Wells will be abandoned flush with the basin liner to facilitate subsequent removal of accumulated solids using a front-end loader. Well screens will be pressure-injected with bentonite grout or filled with bentonite chips in accordance with WAC 173-160. Well casings will be cut off at or below grade and the top 5 ft of each casing will be backfilled with neat cement grout. One or two groundwater monitoring points may be retained for post-injection monitoring, if appropriate.

13.0 SCHEDULE AND REPORTING

Field activities including the design investigation, system construction, system testing, and system startup will be performed between June 26 and September 30, 2006, according to the following anticipated schedule. The anticipated schedule is dependent on the completion of the Agreed Order modification (3rd Amendment), the public comment period, and Ecology's timely review and approval of this work plan. Work in the basin will begin following the removal of accumulated solids to be performed by Boeing in June. If stormwater enters the detention basin following the June removal of accumulated solids, the basin will be pumped out again during the week of June 26. During the week of July 4, any significant thickness of solids that may have accumulated within the work area following the June removal effort will be moved from the work area to the south end of the detention basin. The design investigation will commence immediately after water is removed from the basin and will be completed by July 18. Installation of subgrade system components (i.e., electrodes, vapor monitoring points, and remaining groundwater monitoring points with co-located TMPs) will begin July 19 and be completed by September 1 (6.5 weeks). It is anticipated that installation of system piping and cables will begin prior to completing the installation of electrodes and monitoring points, if advantageous. Pipe and cable installation will be completed by September 15. System startup and testing will be completed by September 30.

The ERH system will begin operation by September 30, 2006 and continue until completion of active heating. The anticipated time of active heating is 82 to 188 days (Table 1). Additional time may be required for implementation of contingency measures.

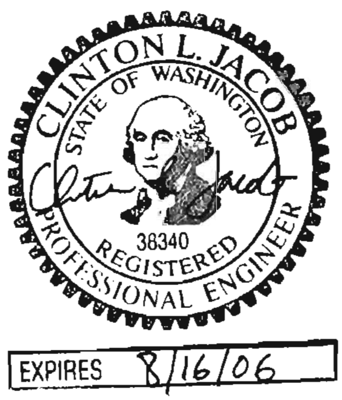
Progress of the IA will be documented in periodic progress reports and in a final ERH report following the end of active heating. Discussion of the source zone IA will be included in the status reports submitted to Ecology every 2 months. A final ERH report will be submitted to Ecology within 150 days following the end of active heating to allow reporting of one round of post-treatment groundwater monitoring data. Any contingency measures to be implemented following active heating (i.e., enhanced biodegradation) will be addressed in the final ERH report. Contingency measures, if employed, will be documented in subsequent reports.

14.0 USE OF THIS WORK PLAN

This Interim Action Work Plan has been prepared for the exclusive use of The Boeing Company for specific application to the Powder Mill Gulch project. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

This document has been prepared under the supervision and direction of the following key staff.

LANDAU ASSOCIATES, INC.



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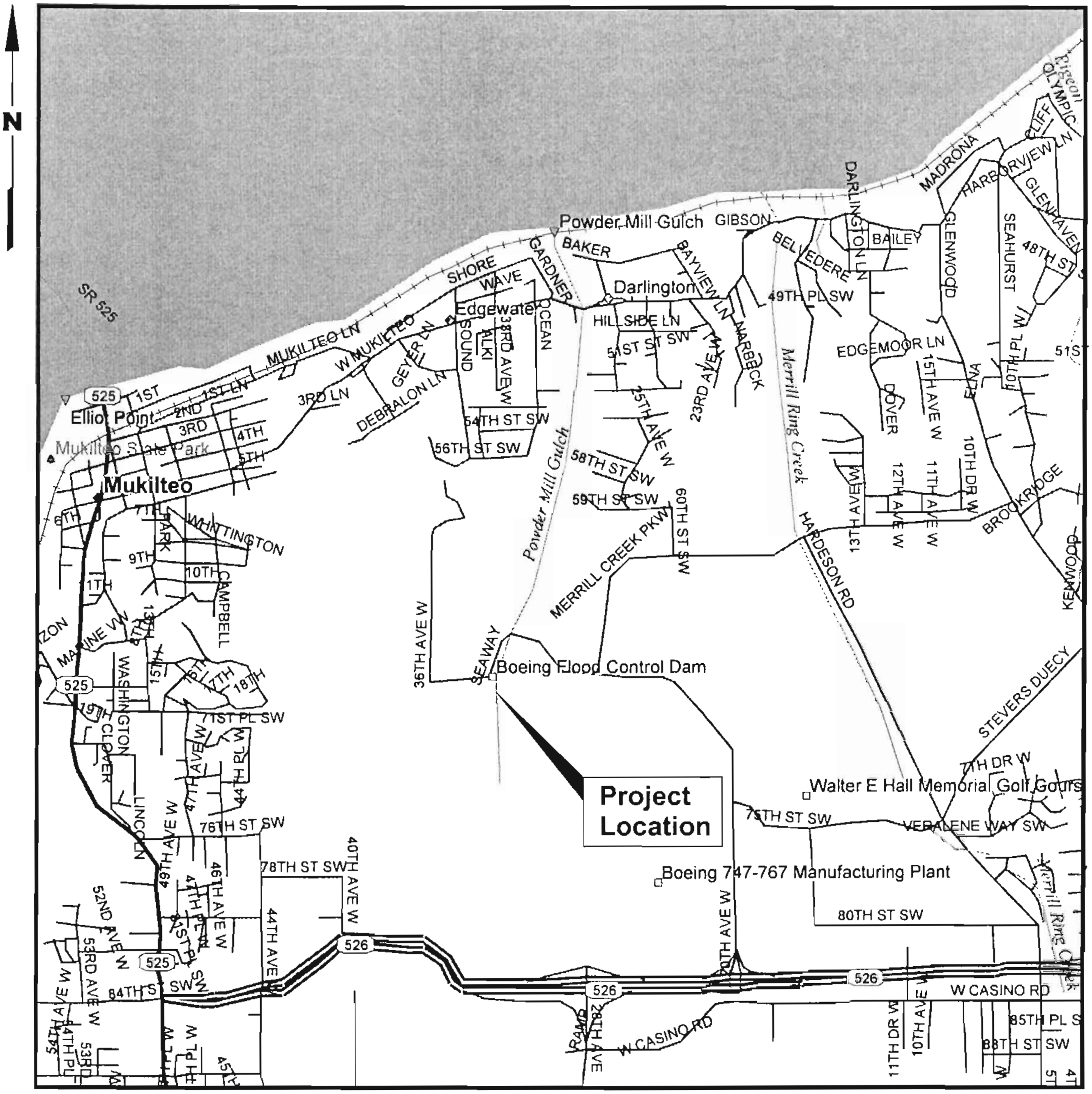

Map from DeLorme Street Atlas USA, 2002

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Scale in Miles

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LANDAU ASSOCIATES

Source Zone Interim Action Boeing Everett, Washington	Vicinity Map	Figure 1

TABLE 1
DESIGN CRITERIA, ASSUMPTIONS, AND CALCULATIONS
SOURCE ZONE INTERIM ACTION WORK PLAN
BOEING EVERETT PLANT, WASHINGTON

Treatment Scenarios:	1	2	3
Electrical Resistance Heating Treatment Area:	14,000 sq. ft.	14,000 sq. ft.	14,000 sq. ft.
Avg. Shallow Extent of Electrical Resistance Heating (a):	15 ft	15 ft	15 ft
Avg. Deep Extent of Electrical Resistance Heating (a):	45 ft	55 ft	70 ft
Typical Depth to Groundwater (a):	15 ft	15 ft	15 ft
Treatment Volume:	15,600 cu yds	20,700 cu yds	28,500 cu yds
Total Organic Carbon Content of Soil:	0.002695	0.002695	0.002695
Number of Electrodes:	50	50	50
Average Distance Between Electrodes:	18 ft	18 ft	18 ft
Average Total Depth of Electrodes (b)	56.5 ft	66.5 ft	81.5 ft
Depth to Top of Electrodes (a):	17 ft	17 ft	17 ft
Number of Co-located Vapor Recovery Wells:	50	50	50
Number of Temperature Monitoring Points:	10 (7 sensors each)	10 (9 sensors each)	10 (12 sensors each)
Controlling Contaminant:	TCE	TCE	TCE
Average Clean-up Percent:	0.991935484	0.991935484	0.991935484
Condensate Production Rate:	5.9 gpm	6.8 gpm	7.9 gpm
Assumed Activated Carbon Required:	6,000 lbs	8,000 lbs	11,000 lbs
Power Control Unit (PCU) Capacity:	2000 kW	2000 kW	2000 kW
Average Electrical Heating Power Input:	1122 kW	1266 kW	1446 kW
Total Heating Treatment Time:	82 - 137 days	96 - 158 days	115 - 188 days
Design Remediation Energy (kW-hr):	2467000	3239000	4441000
Number of Monitoring Wells:	10	10	10

(a) Depths indicated are below basin bottom (BBB).
(b) Average depths account for deeper drilling at locations on slope of basin embankment.

DRAFT

TABLE 2
ERH WELL DETAILS
SOURCE ZONE INTERIM ACTION WORK PLAN
BOEING EVERETT PLANT, WASHINGTON

Well ID	Ground Elevation (ft)	Total Depth BBB (ft) (a)	Drilling on Slope?
Electrode/Vapor Recovery Wells (50):			
E8	362.5	91.0	YES
F8	362.5	91.0	YES
C7	361.8	90.3	YES
D7	359.5	88.0	YES
E7	358.0	86.5	YES
F7	356.8	85.3	YES
G7	356.2	84.7	YES
H7	358.0	86.5	YES
J7	359.5	88.0	YES
C6	357.5	86.0	YES
D6	355.5	84.0	YES
E6	353.0	81.5	YES
F6	351.5	80.0	YES
G6	350.5	79.0	YES
H6	351.3	79.8	YES
J6	353.5	82.0	YES
K6	355.0	83.5	YES
C5	353.5	82.0	YES
D5	351.0	79.5	YES
E5	349.2	77.7	YES
F5	346.4	74.9	YES
G5	344.9	73.4	YES
H5	344.7	73.2	YES
J5	346.6	75.1	YES
K5	349.2	77.7	YES
C4	348.6	77.1	YES
D4	346.4	74.9	YES
E4	343.5	72.0	YES
F4	341.5	70.0	NO
G4	341.5	70.0	NO
H4	341.5	70.0	NO
J4	341.5	70.0	NO
K4	341.8	70.3	YES
C3	343.4	71.9	YES
D3	341.5	70.0	NO
E3	341.5	70.0	NO
F3	341.5	70.0	NO
G3	341.5	70.0	NO
H3	341.5	70.0	NO
J3	341.5	70.0	NO
K3	341.5	70.0	NO
L3	341.5	70.0	NO
D2	341.5	70.0	NO
E2	341.5	70.0	NO
F2	341.5	70.0	NO
G2	341.5	70.0	NO

DRAFT

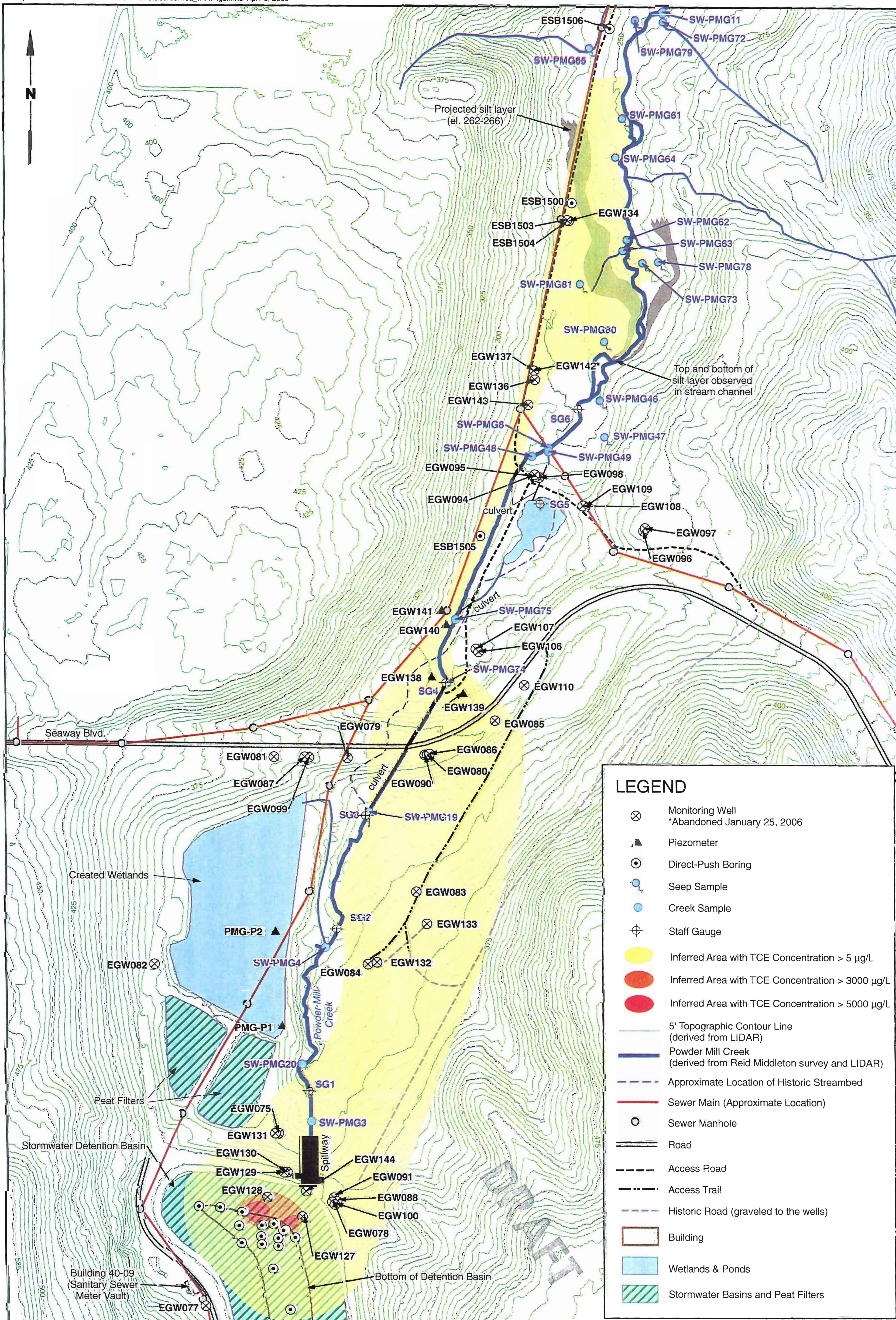
TABLE 2
ERH WELL DETAILS
SOURCE ZONE INTERIM ACTION WORK PLAN
BOEING EVERETT PLANT, WASHINGTON

Well ID	Ground Elevation (ft)		Total Depth BBB (ft) (a)	Drilling on Slope?
H2	341.5		70.0	NO
J2	341.5		70.0	NO
K2	341.5		70.0	NO
L2	341.5		70.0	NO
		Total	3826.9	30
Nested Groundwater Monitoring Wells (10) (b):				
E07	355.0		85.5	YES
G07	355.0		85.5	YES
D06	353.0		83.5	YES
F06	349.3		79.8	YES
H06	350.0		80.5	YES
E05	345.1		75.6	YES
D04	343.2		73.7	YES
F04	341.5		72.0	NO
J04	341.5		72.0	NO
F03	341.5		72.0	NO
		Total	780.1	7
Vacuum Monitoring Wells (4):				
PZ-C9	365.0		46.5	YES
PZ-K7	360.5		42.0	YES
PZ-B6	358.5		40.0	YES
PZ-G1	341.5		23.0	NO
		Total	151.5	3

(a) Below Basin Bottom (BBB). Elevation at basin bottom is 341.5 ft.
(b) Groundwater monitoring wells to be completed above grade at elevation 352 ft.

DRAFT

Y:\Projects\025175\010\MapDocs\WorkPlans\SourceArea_IRA\Fig2.mxd April 3, 2006



0 200 400

Scale in Feet

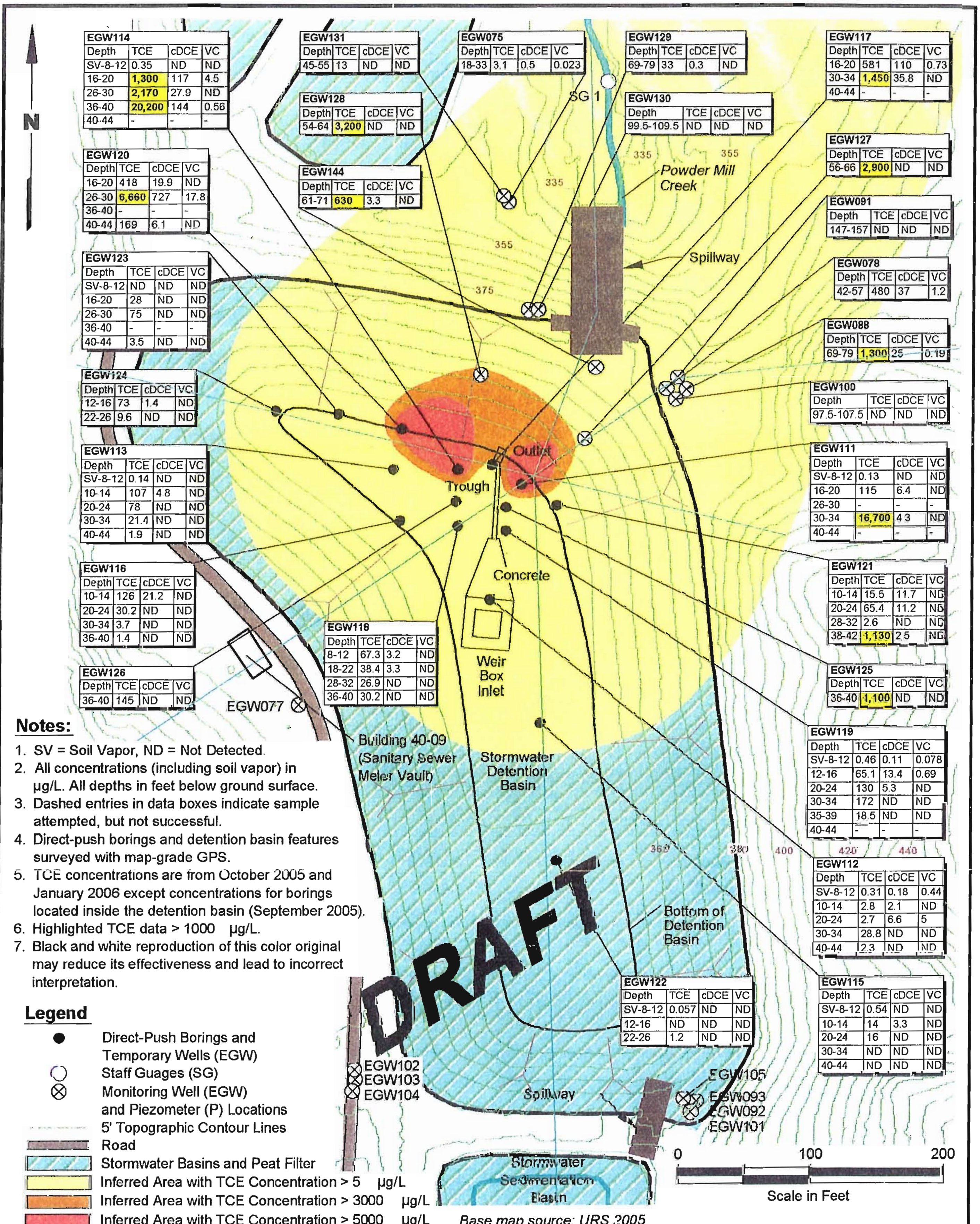
LANDAU ASSOCIATES

Note

1) Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Base map sources: URS 2005; City of Everett 2005
LIDAR data source: URS 2005 (Data collected November 2005)

Source Zone Interim Action Boeing Everett, Washington	**Site Plan**	Figure 2



Notes:

1. SV = Soil Vapor, ND = Not Detected.
2. All concentrations (including soil vapor) in µg/L. All depths in feet below ground surface.
3. Dashed entries in data boxes indicate sample attempted, but not successful.
4. Direct-push borings and detention basin features surveyed with map-grade GPS.
5. TCE concentrations are from October 2005 and January 2006 except concentrations for borings located inside the detention basin (September 2005).
6. Highlighted TCE data > 1000 µg/L.
7. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend

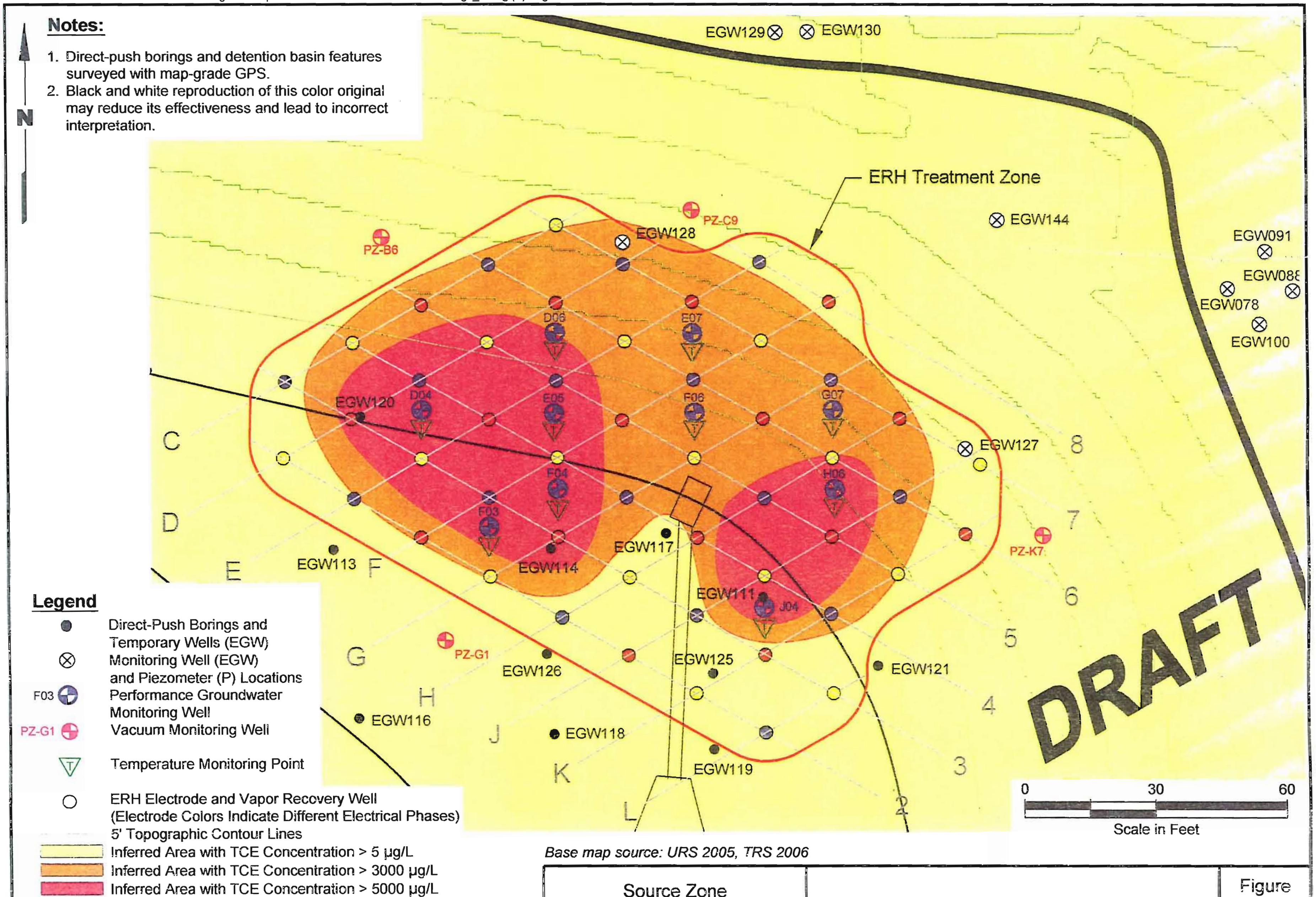
- Direct-Push Borings and Temporary Wells (EGW)
- Staff Guages (SG)
- Monitoring Well (EGW) and Piezometer (P) Locations
- 5' Topographic Contour Lines
- Road
- Stormwater Basins and Peat Filter
- Inferred Area with TCE Concentration > 5 µg/L
- Inferred Area with TCE Concentration > 3000 µg/L
- Inferred Area with TCE Concentration > 5000 µg/L

Base map source: URS 2005

NOT FOR PRODUCTION Boeing Everett | T:\025\175\010\Source Zone 1A WP\Fig3_4.dwg (A) "Figure 3" 3/29/2006

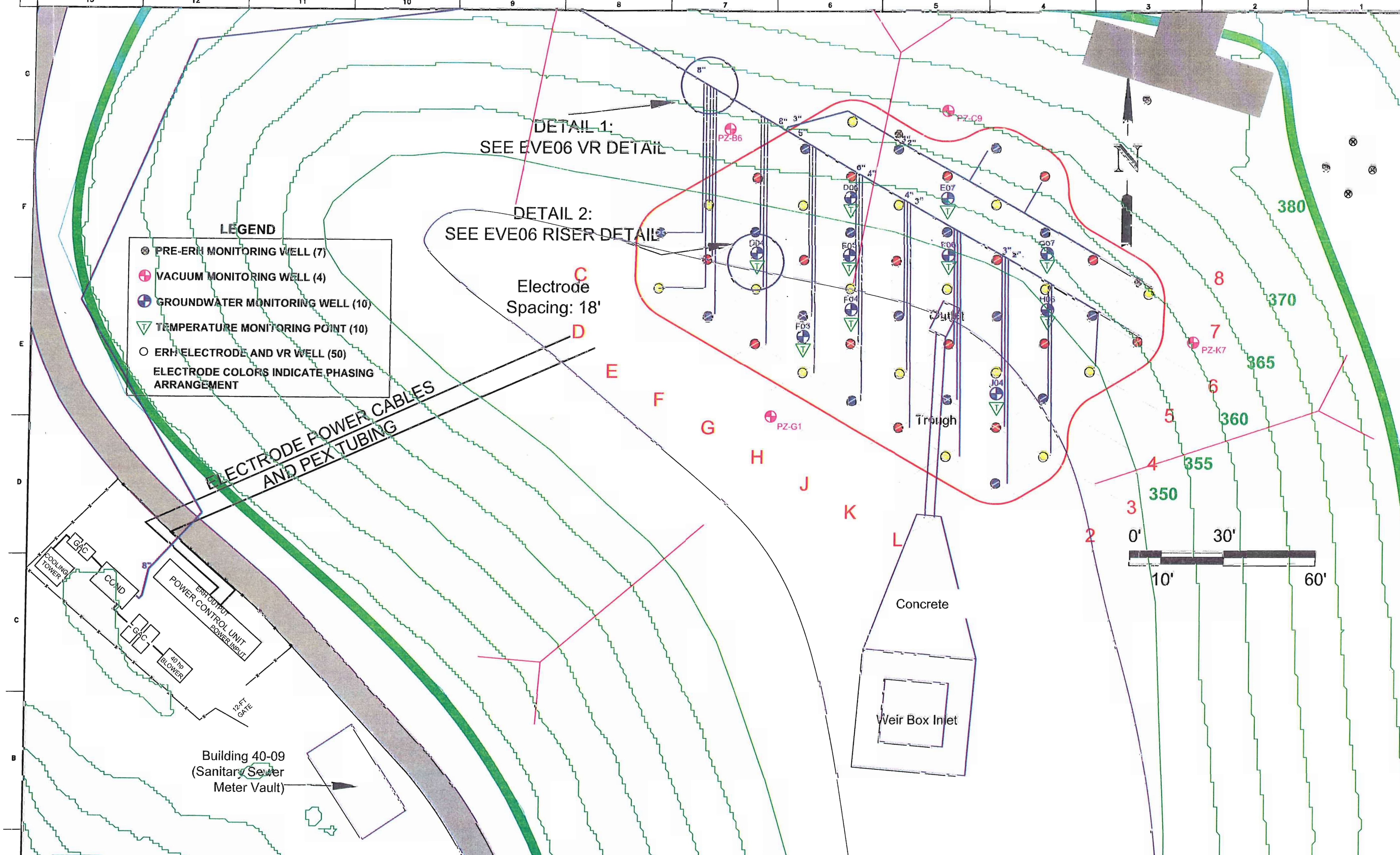
LANDAU ASSOCIATES	Source Zone Interim Action Boeing Everett, Washington	**Source Area VOC Concentrations in Groundwater and Soil Vapor**	Figure **3**

NOT FOR PRODUCTION Boeing Everett | T:\025\175\010\Source Zone 1A WP\Fig3_4.dwg (A) "Figure 4" 3/29/2006



LANDAU ASSOCIATES

Source Zone Interim Action Boeing Everett, Washington	**ERH Treatment Area**	Figure 4



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REVISION REFERENCE NO	DRAWING TITLE
DCR-EVE06-04	PLOT PLAN
DCR-EVE06-02	PLOT PLAN
DCR-EVE06-02	PLOT PLAN

REFERENCE DRAWINGS

DATE: 3/22/06

NO	DESCRIPTION	QA BY / DATE	BY / DATE	CHK BY / DATE	REV BY / DATE
0	SUBMITTED TO CLIENT		CDC 3/15/06		CDC 3/15/06
A	DESIGN REVIEW 3/03/06 GB, CC, JW, TP, DS		CDC 2/28/06		CDC 2/28/06
A	DESIGN REVIEW 3/03/06 GB, CC, JW, TP, DS		CDC 2/28/06		CDC 2/28/06

REVISIONS

CADFILE

DRAWN: C. CROWNOVER
CHECKED
DFTG APVD
ENGR: C. CROWNOVER
PROJECT MANAGER
OTHER
APPROVED FOR IMPLEMENTATION
BY
FOR DATE

EVE06

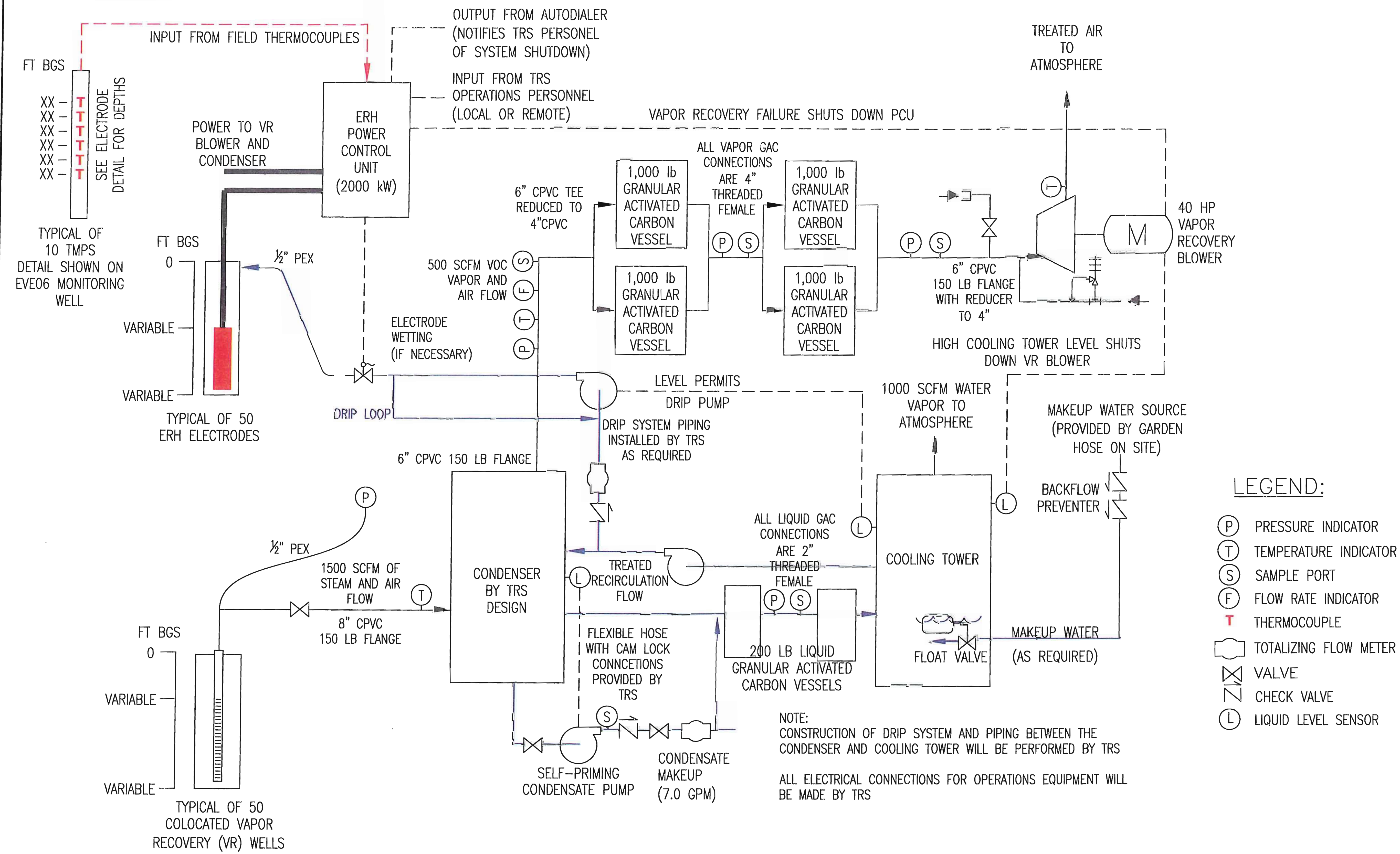
PLOT PLAN

EVERETT, WA

SCALE

DWG NO EVE06-PP-01

REV 0A



NOTE:
CONSTRUCTION OF DRIP SYSTEM AND PIPING BETWEEN THE CONDENSER AND COOLING TOWER WILL BE PERFORMED BY TRS

ALL ELECTRICAL CONNECTIONS FOR OPERATIONS EQUIPMENT WILL BE MADE BY TRS

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REFERENCE NO	DRAWING TITLE	RR	MF	QA BY / DATE	BY / DATE	CHK BY / DATE	REV BY / DATE	DESCRIPTION	NO
DCR–EVE06–04	Process Flow Diagram				CDC 3/15/06		CDC 3/15/06	SUBMITTED TO CLIENT	0
DCR–EVE06–03	P & ID				CDC 3/09/06		CDC 3/09/06	SUBMITTED TO CLIENT	B
DCR–EVE06–02	P & ID				CDC 2/28/06		CDC 2/28/06	DESIGN REVIEW 3/03/06 GB,CC,JW,TP,DS	A

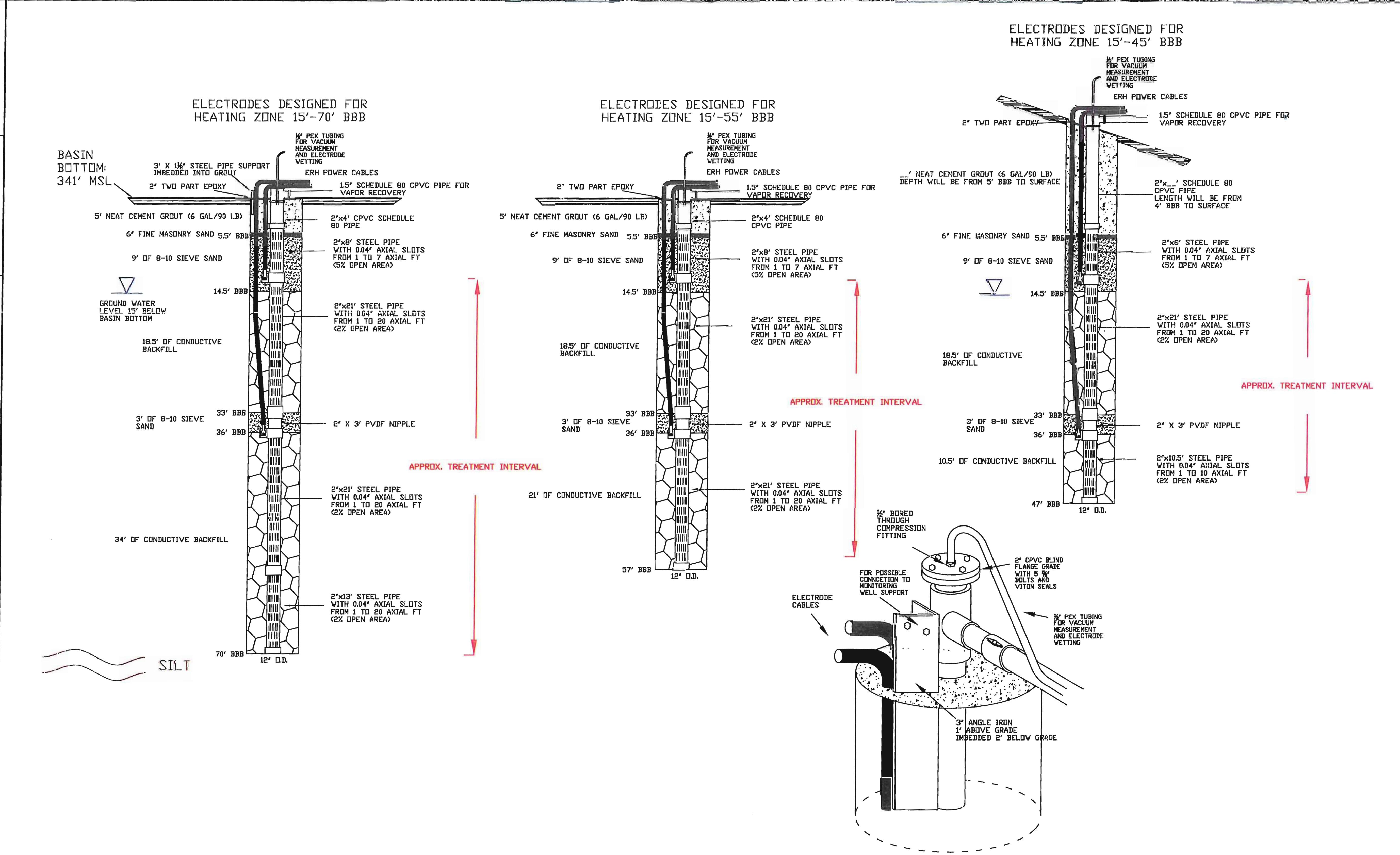
REFERENCE DRAWINGS — REVISIONS

DATE: 3/22/06

DRAWN: C CROWNOVER — DATE 3/01/06
CHECKED
DFTG APVD
ENGR: C CROWNOVER — 3/01/06
PROJECT MANAGER
OTHER
QA
APPROVED FOR IMPLEMENTATION
BY / FOR / DATE

EVE06
Process Flow Diagram
Everett, WA

SCALE: NONE
SHEET 1 OF 1
DWG NO: EVE06 PFD 01
REV: 0A



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REFERENCE NO	DRAWING TITLE	RR	MF	QA BY / DATE	ENGR BY / DATE	CHK BY / DATE	REV BY / DATE	DESCRIPTION	REV NO
DCR-EVE06-04	ELECTRODE DETAIL				CDC 3/15/06		CDC 3/15/06	SUBMITTED TO CLIENT	0
DCR-EVE06-03	ELECTRODE DETAIL				CDC 3/09/06		CDC 3/09/06	SUBMITTED TO CLIENT	B
DCR-EVE06-02	ELECTRODE DETAIL				CDC 2/28/06		CDC 3/03/06	DESIGN REVIEW 3/03/06 GB, CC, JW, TP, DS	A

REFERENCE DRAWINGS — REVISIONS

DATE: 3/09/06 — CADFILE EVE06 ELECTRODE DETAIL

DRAWN: C CROWNOVER
CHECKED
DFTG APVD
ENGR: C CROWNOVER
PROJECT MANAGER
OTHER
QA
APPROVED FOR IMPLEMENTATION BY / DATE

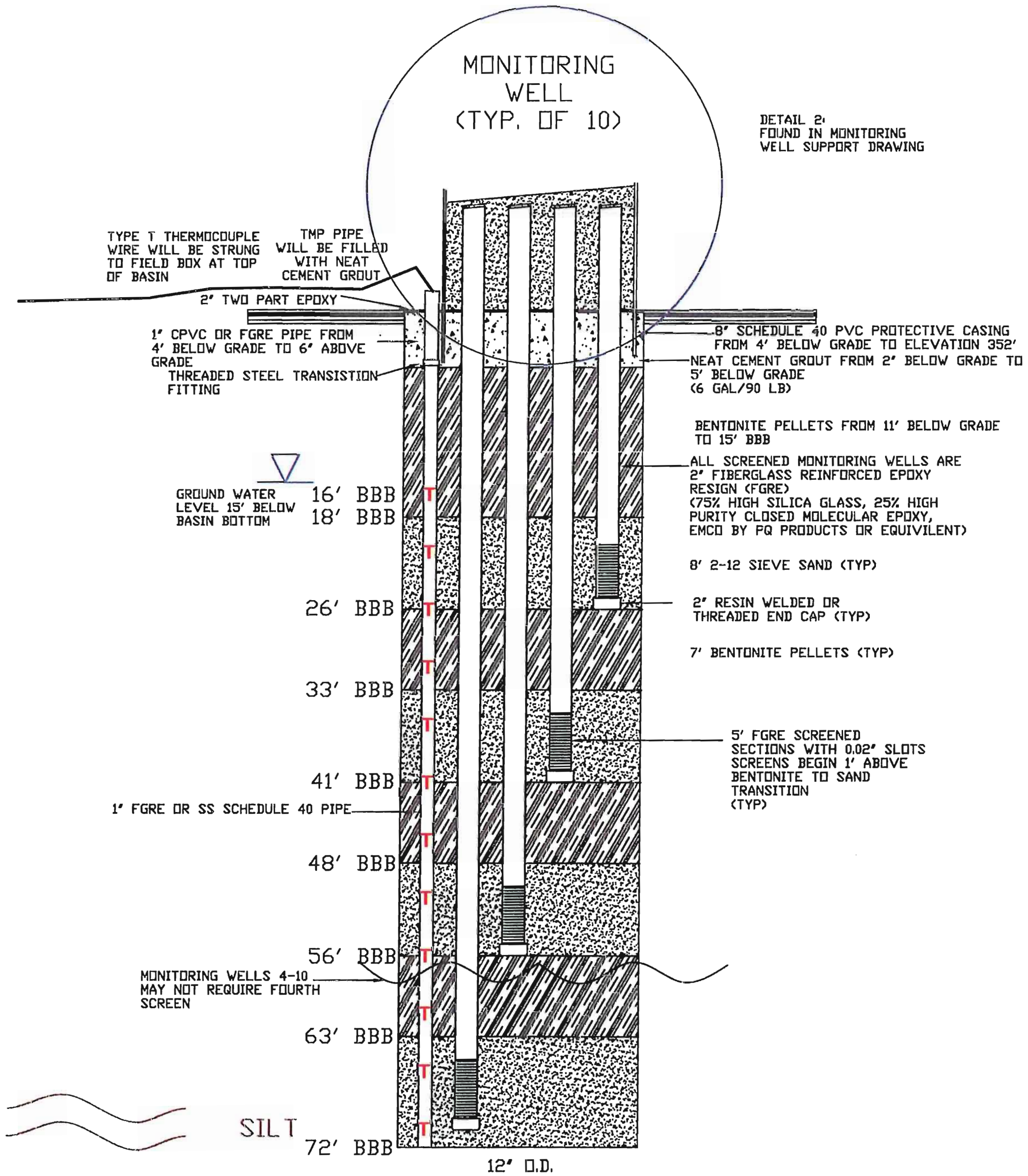
EVE06

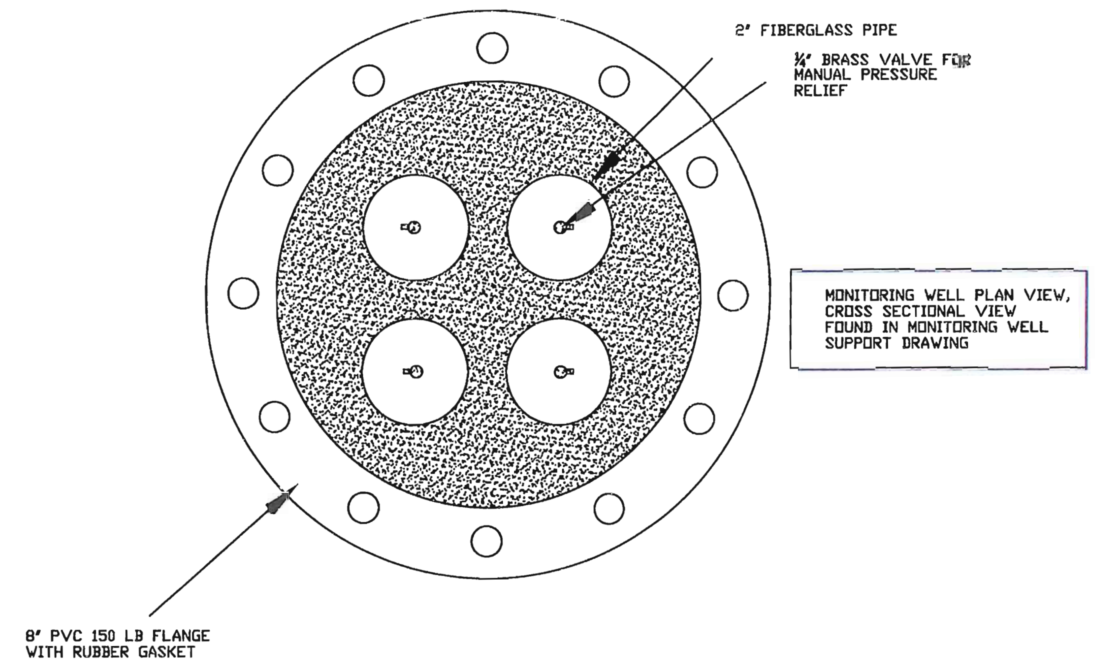
ELECTRODE DETAIL

EVERETT, WA

SCALE: NONE

DWG NO: EVE06-ED — 0A





T = THERMOCOUPLE (INSTALLED AFTER DRILLING IS COMPLETE)
THERMOCOUPLES AT 5' SPACING STARTING AT 16' BBB
TMP = TEMEPERATURE MONITORING POINT

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GREGORY L. BEYKE — STATE OF WASHINGTON — PROFESSIONAL ENGINEER

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REVISION REFERENCE NO	DRAWING TITLE	RR	MF	QA BY / DATE	ENGR BY / DATE	CHK BY / DATE	REV BY / DATE	DESCRIPTION	NO
DCR-EVE06-04	MONITORING WELL				CDC 3/15/06		CDC 3/15/06	SUBMITTED TO CLIENT	0
DCR-EVE06-03	MONITORING WELL				CDC 3/09/06		CDC 3/09/06	SUBMITTED TO CLIENT	A
DCR-EVE06-02	MONITORING WELL				CDC 3/03/06		CDC 3/03/06	PROJECT START EVE06 ES 022406 EVE06 PT 022006	

REFERENCE DRAWINGS — REVISIONS

DATE: 3/21/06 — CADFILE

DRAWN	C CROWNOVER	3/03/06
CHECKED		
DFTG APVD		
ENGR	C CROWNOVER	3/03/06
PROJECT MANAGER		
OTHER		
QA		
APPROVED FOR IMPLEMENTATION BY		DATE

EVE06

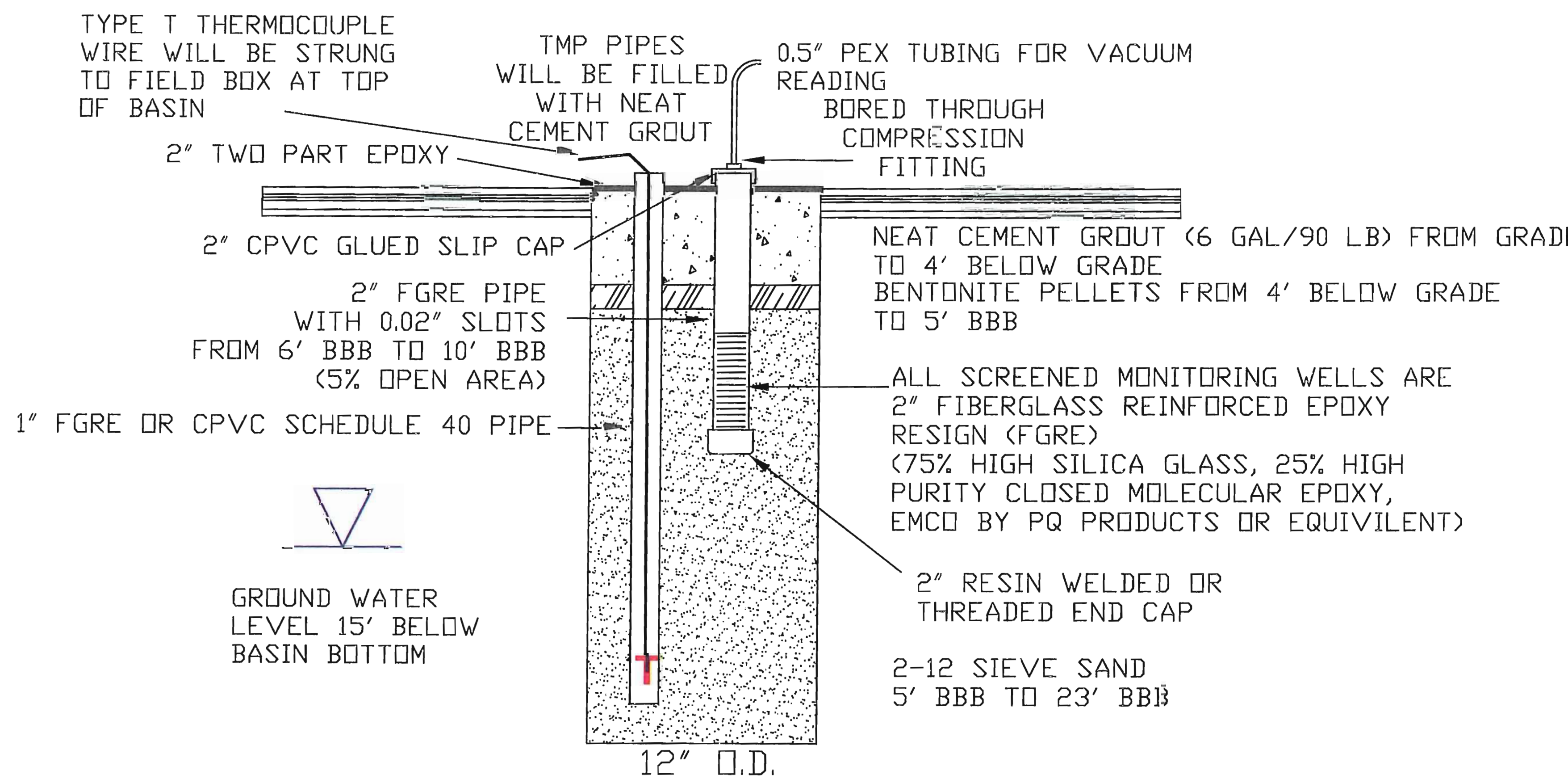
MONITORING WELL

EVERETT, WA

SCALE NONE — SHEET NO 2 of 5

DWG NO EVE06-ED — REV 0A

VACUUM MONITORING WELL (TYP. OF 4)



T = THERMOCOUPLE (INSTALLED AT 20' BBB)
TMP = TEMEPERATURE MONITORING POINT

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REVISION/REFERENCE NO	DRAWING TITLE	RR	MF	QA BY / DATE	ENGR BY / DATE	CHK BY / DATE	REV BY / DATE	DESCRIPTION	REV NO
DCR-EVE06-04	VACUUM MONITORING WELL				CDC 3/15/06		CDC 3/15/06	SUBMITTED TO CLIENT	0
DCR-EVE06-03	VACUUM MONITORING WELL				CDC 3/09/06		CDC 3/09/06	SUBMITTED TO CLIENT	A
DCR-EVE06-02					CDC 3/03/06		CDC 3/03/06	PROJECT START	

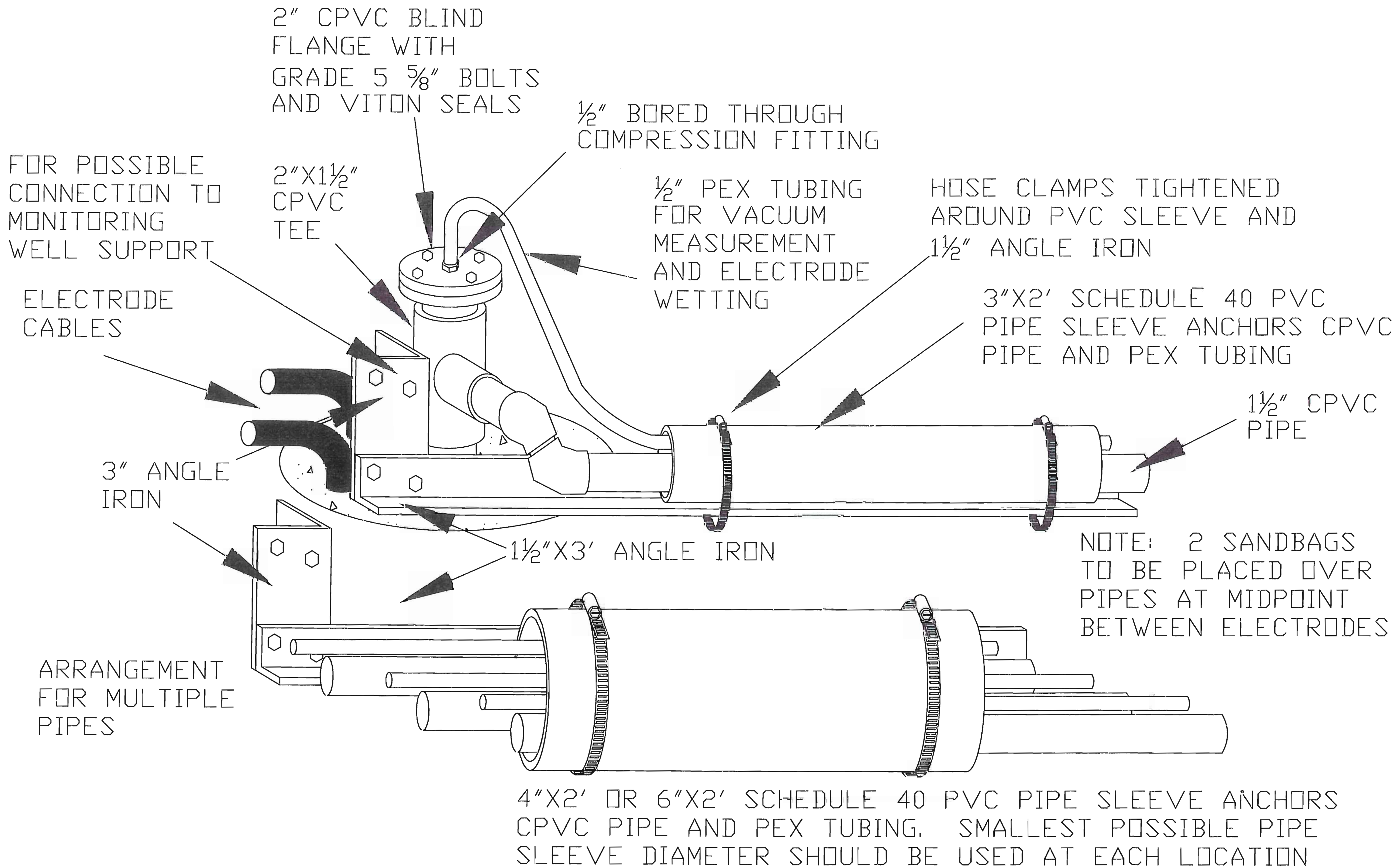
REFERENCE DRAWINGS — REVISIONS

DATE: 3/09/06

DRAWN: C CROWNOVER
CHECKED
DFTG APVD
ENGR: C CROWNOVER
PROJECT MANAGER
OTHER
APPROVED FOR IMPLEMENTATION
BY / DATE

EVE06
VACUUM MONITORING WELL
EVERETT, WA

SCALE: NONE | SHEET NO 3 OF 5
DWG NO EVE06-ED | REV 0A



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REFERENCE NO	DRAWING TITLE	RR	MF	QA BY DATE	ENGR BY DATE	CHK BY DATE	REV BY DATE	DESCRIPTION	REV NO
DCR-EVE06-04	PIPING AND ELECTRODE DETAIL				CDC 3/15/06		CDC 3/20/06	SUBMITTED TO CLIENT	0A
DCR-EVE06-04	PIPING AND ELECTRODE DETAIL				CDC 3/15/06		CDS 3/15/06	SUBMITTED TO CLIENT	0

REFERENCE DRAWINGS — REVISIONS

DATE: 3/14/06 — CADFILE

DRAWN: C CROWNOVER 3/13/06
CHECKED
DFTG APVD
ENGR: C CROWNOVER 3/13/06
PROJECT MANAGER
QA
APPROVED FOR IMPLEMENTATION

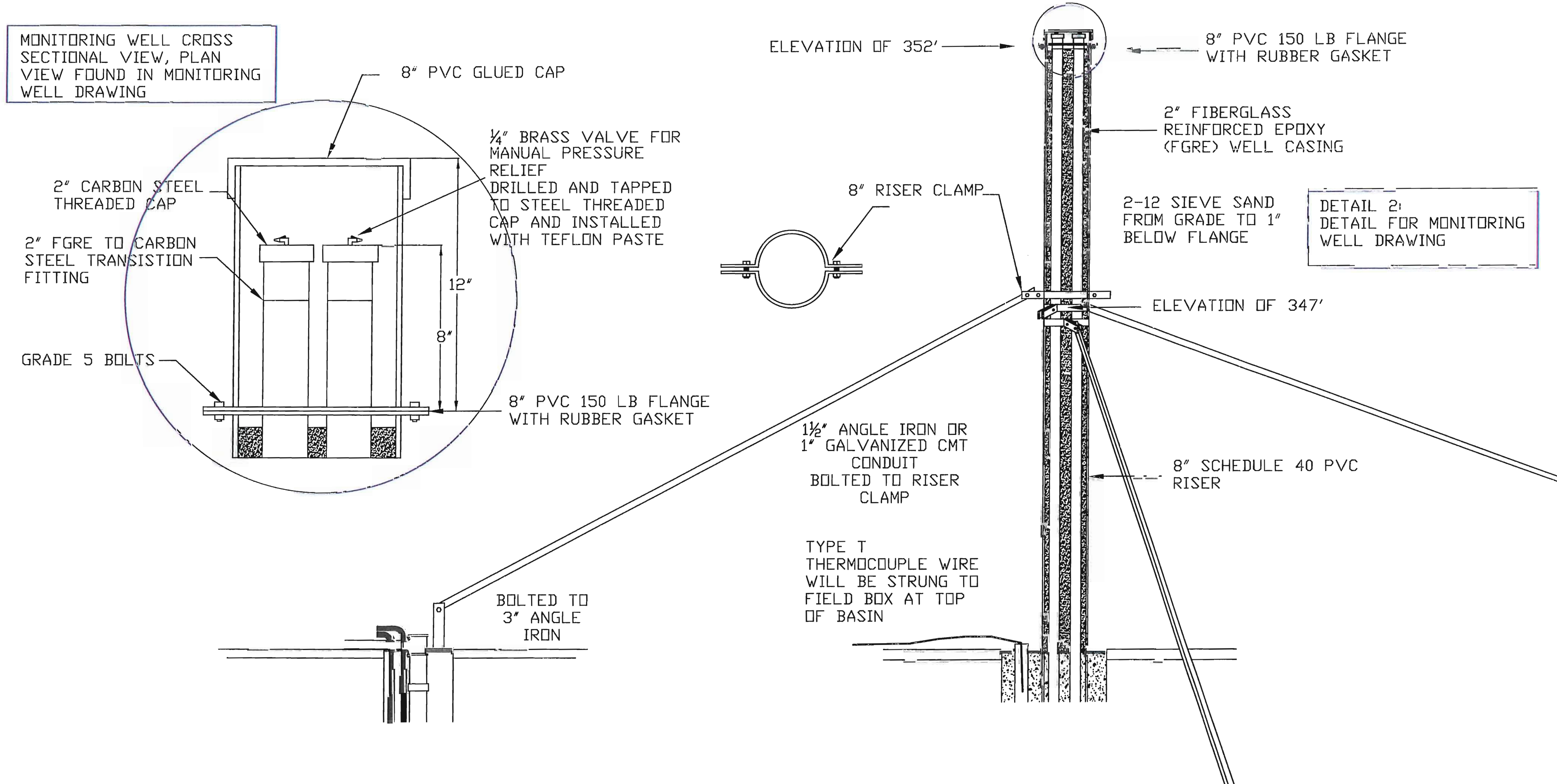
EVE06

PIPING AND ELECTRODE DETAIL

EVERETT, WA

SCALE: NONE — SHEET 4 OF 5

DWG NO EVE06-ED — REV 0A



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REFERENCE DRAWINGS		REVISIONS							
DCR-EVE06-04	MONITORING WELL SUPPORT			CDC 3/15/06		CDC 3/15/06		SUBMITTED TO CLIENT	0
REFERENCE NO	DRAWING TITLE	RR	MF	QA BY DATE	ENGR BY DATE	CHK BY DATE	DRAWN BY DATE	DESCRIPTION	NO

DATE: 3/21/06

DRAWN	C CROWNOVER	3/15/06
CHECKED		
DFTG APVD		
ENGR	C CROWNOVER	3/15/06
PROJECT MANAGER		
OTHER		
QA		
APPROVED FOR IMPLEMENTATION BY		DATE

EVE06

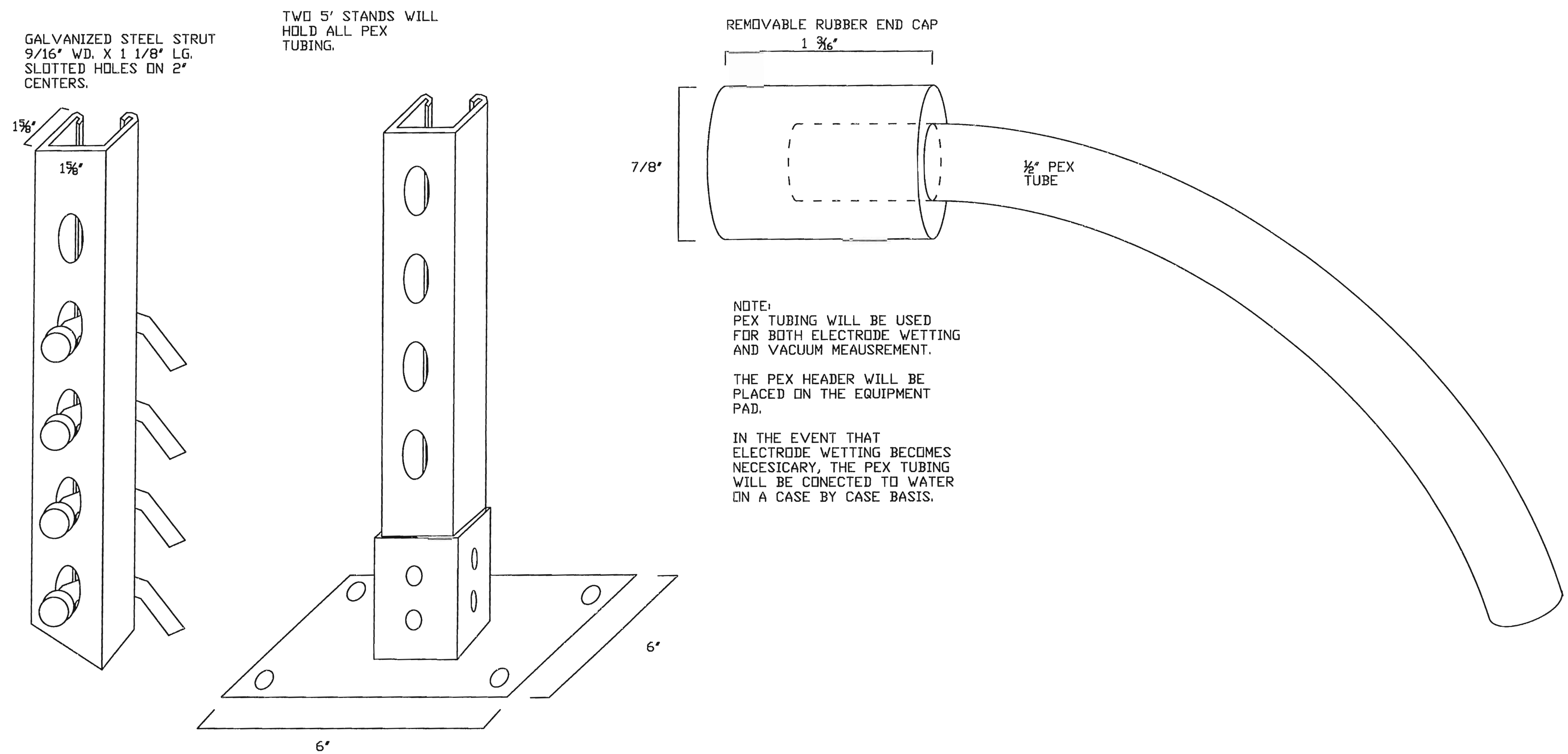
MONITORING WELL SUPPORT

EVERETT, WASHINGTON

SCALE NONE

DWG NO EVE06-ED

REV 0A



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REFERENCE NO	DRAWING TITLE
DCR-EVE06-04	PEX

REFERENCE DRAWINGS

DATE: 3/16/06

REV NO	DESCRIPTION	DA BY / DATE	ENGR BY / DATE	CHK BY / DATE	REV BY / DATE
0	SUBMITTED TO CLIENT	CDC 3/15/06		CDC 3/15/06	

REVISIONS

CADFILE

DRAWN: C CROWNOVER
CHECKED
DFTG APVD
ENGR: C CROWNOVER
PROJECT MANAGER
OTHER
QA
APPROVED FOR IMPLEMENTATION
BY
DATE

EVE06

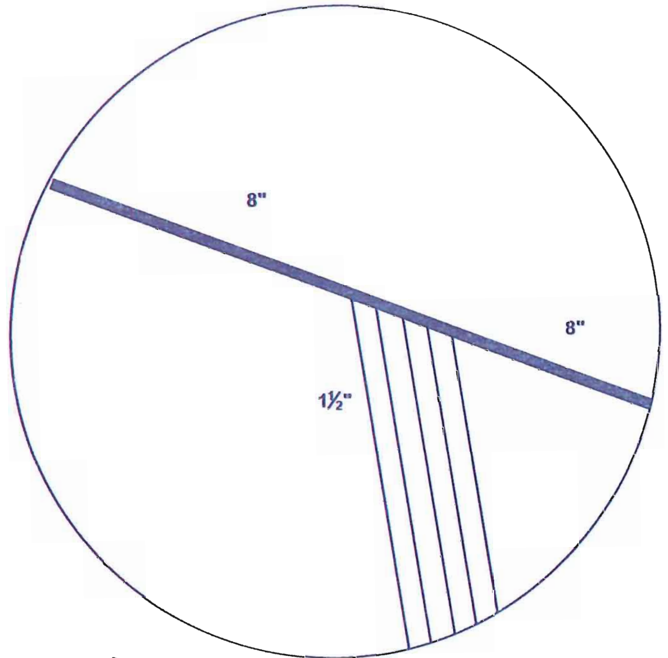
PEX

EVERETT, WASHINGTON

SCALE NONE

DWG NO EVE06 VR DETAIL

REV 0A



DETAIL 1:
FROM DRAWING EVE06 PLOT PLAN

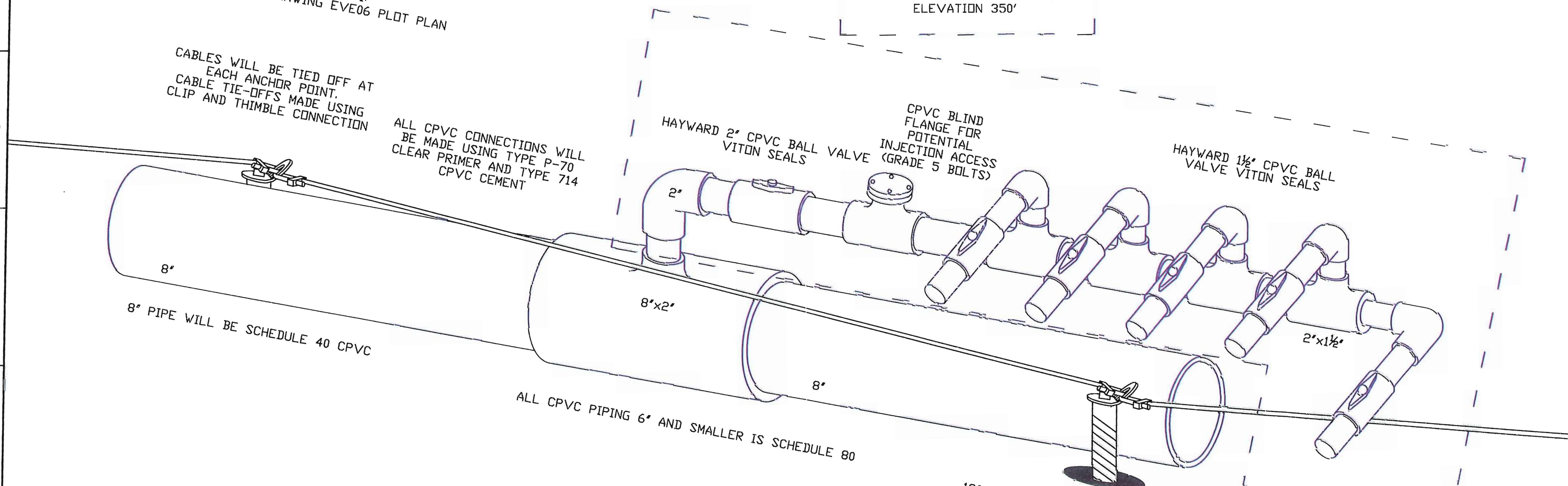
NOTE:
ALL PIPES AND FITTINGS WILL BE PRESSURE TESTED BEFORE APPLYING POWER TO THE ELECTRODES

NOTE:
ALL 2" TO 8" HEADER PIPE WITHIN BASIN TO BE ANCHORED BY ¼" GALVANIZED STEEL CABLE AND EARTH ANCHORS

CABLE WILL BE TIED DOWN AT 18" LONG ALUMINUM SCREW EARTH ANCHORS (AMERICAN EARTH ANCHORS OR EQUIVALENT)

ANCHORS TO BE PLACED ON 10' CENTERS AND ON ALTERNATING SIDES OF THE PIPING AS SHOWN BELOW

THIS PIPING HEADER ARRANGMENT WILL BE TYPICAL FOR PIPING TO ALL WELL HEADS AT OR BELOW ELEVATION 350'



8" PIPE WILL BE SCHEDULE 40 CPVC

ALL CPVC PIPING 6" AND SMALLER IS SCHEDULE 80

18" ALUMINUM EARTH ANCHOR POINT PENETRATION TO BE SEALED WITH ASPHALT MASTIC

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REFERENCE NO	DRAWING TITLE	RR	MF	QA BY / DATE	ENGR BY / DATE	CHK BY / DATE	REV BY / DATE	DESCRIPTION	REV NO
DCR-EVE06-04	VAPOR RECOVERY DETAIL				CDC 3/15/06		CDC 3/15/06	SUBMITTED TO CLIENT	0
DCR-EVE06-03	VAPOR RECOVERY DETAIL				GB 3/10/06		CDC 3/10/06	SUBMITTED TO CLIENT FOR BROAD VIEW SEE PLOT PLAN	A

REFERENCE DRAWINGS — REVISIONS

DATE: 3/10/06 — CADFILE

DRAWN	G BEYKE	3/10/06
CHECKED		
DFTG APVD		
ENGR	G BEYKE	3/10/06
PROJECT MANAGER		
OTHER		
QA		
APPROVED FOR IMPLEMENTATION BY		DATE

EVE06

VAPOR RECOVERY DETAIL

EVERETT, WASHINGTON

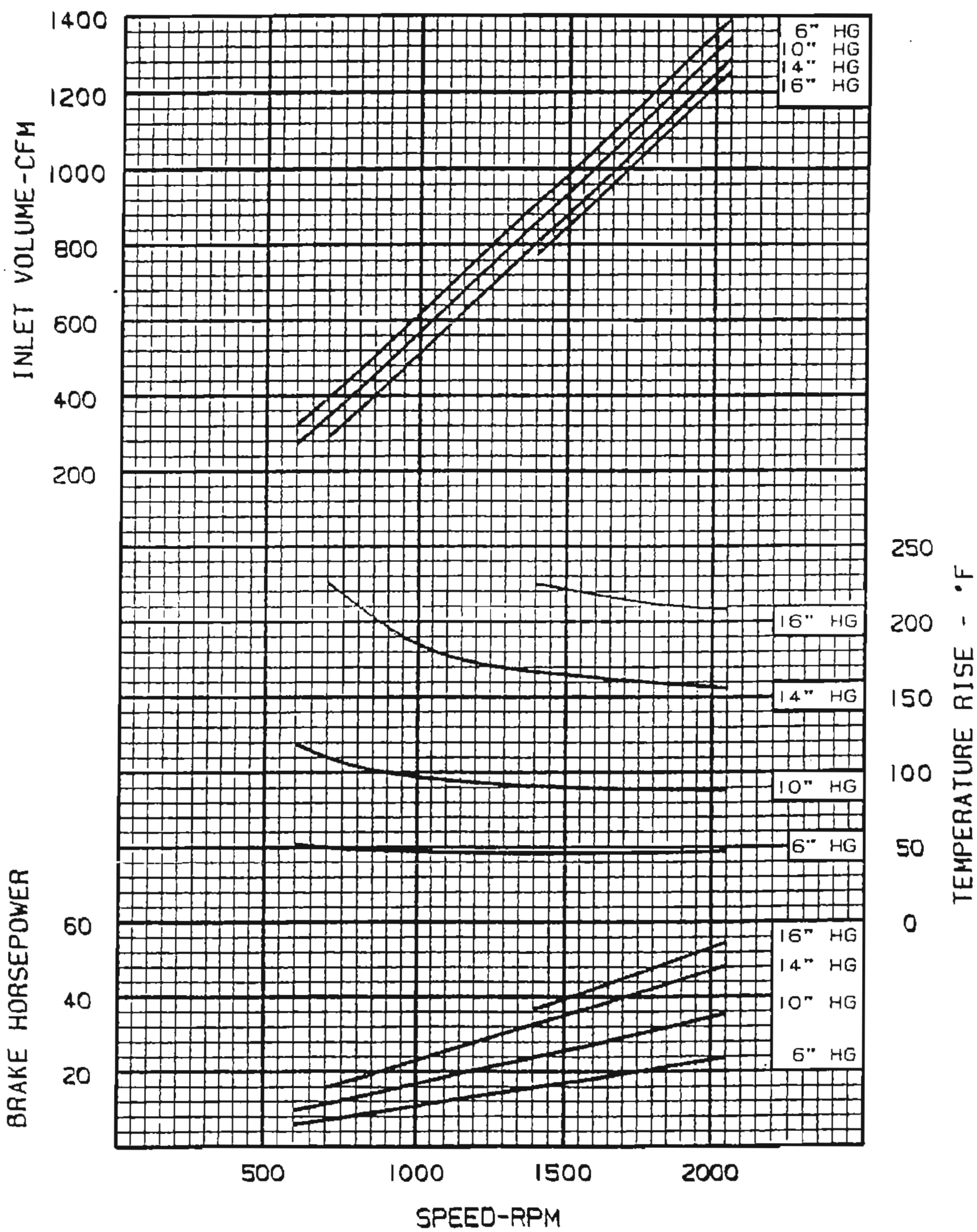
SCALE NONE — SHEET NO 1 OF 2

DWG NO EVE06 VR DETAIL — REV 0A

DRESSER INDUSTRIES, INC.
ROOTS DIVISION
900 WEST MOUNT STREET
CONNERSVILLE, INDIANA 47331
PRINTED IN U.S.A.

PERFORMANCE BASED ON
INLET AIR = 68°F
DISCHARGE PRESSURE = 30" HG ABS.
JULY, 1994

VACUUM PERFORMANCE
FRAME 711 UNIVERSAL RAI BLOWER
MAXIMUM VACUUM=16 IN. HG
MAXIMUM SPEED=2050 RPM



USFILTER WESTATES CARBON VSC-SERIES VAPOR PHASE ADSORBERS

Benefits and Design Features

- *Durable, carbon steel construction*
- *Abrasion and corrosion resistant baked epoxy lining; urethane exterior finish (VSC-1000, 2000, 3000, 8000)*
- *Ready-to-use systems: simple installation and operation*
- *Applications to 3000 SCFM*
- *The VSC-1000, 2000, 3000 and 8000 adsorbers have forklift channels for easy handling*
- *The VSC-200, 400, 1000 and 2000 adsorbers are UN/DOT approved transportation containers for RCRA hazardous spent carbon*
- *Hose kit and pipe manifold options are available to simplify installation and operation*

Piping Manifold (Optional)

- *2"/3" sch 80 PVC piping and valves (optional carbon steel and stainless steel piping)*
- *Series or parallel operation.*
- *Sampling ports and pressure gauges*
- *Flexible hoses with Kamlock fittings allow easy installation and removal during service exchange operations (VSC-200, 400, 1000 and 2000).*

Applications

The VSC-Series adsorbers have been proven to be the simplest and most cost effective way to treat malodorous and VOC emission problems. Sturdy steel construction and specially formulated corrosion resistant internal coating ensures long service life and low maintenance. VSC-Series applications include:

- API separator vents
- VOC control from soil vapor extraction (SVE) systems and airstrippers
- Wastewater and product storage tank vents
- Process vents
- Refinery and chemical plant wastewater sewer vents
- Laboratory hood exhausts

Installation, Startup and Operation

USFilter can provide a total service package that includes utilizing OSHA trained personnel providing on-site carbon changeouts, packaging and transportation of spent carbon for recycling at our reactivation facilities, where the contaminants are thermally destroyed.

We provide instructions on sampling the spent carbon and completion of our spent carbon profile form. Spent carbon acceptance testing can be performed at our certified laboratory.

When requested, a certificate of reactivation will be issued.

USFilter

VSC-SERIES
VAPOR PHASE ADSORBERS

TO BE USED AT EVERETT POWDER MILL GULCH SITE

SPECIFICATIONS

	VSC-200	VSC-400	VSC-1000/2000	VSC-3000	VSC-8000
Dimensions, diameter x overall height	22" x 34"	30" x 43"	48" x 56"/48" x 8' 0"	60" x 9' 3"	96" x 11' 0"
Inlet Connection	2" FNPT	4" FNPT	4" FNPT	10" Flange	12" Flange
Outlet Connection	2" MPT	4" FNPT	4" FNPT	10" Flange	12" Flange
Manway	Top	Top	18" Top	16" Top	20" Top/Side
Internal Distribution[1]	PVC	PVC	PVC	FRP/PPL	FRP/PPL
Interior Coating	Epoxy	Epoxy	Epoxy	Epoxy	Epoxy
Exterior Coating	Enamel	Enamel	Epoxy/Urethane	Epoxy/Urethane	Epoxy/Urethane
Carbon Fill Volume (cu.ft.)	6.8	14	34/68	107	273
Cross Sectional Area (sq.ft.)	2.8	4.9	12.3	19.6	50.2
Approx. Carbon Weight (lbs)	200	400	1000/2000	3000	8000
Empty Vessel Weight	250	480	890/1190	2500	4500
Flow, CFM (max.)	100	300	500	1500	3750
Pressure, psig (max.)	3	3	14.9	5	5
Temperature, deg. F (max)[4]	140	140	140	140	140
Vacuum, in. Hg (max.)	N/A	N/A	12/12[2]	6[3]	12[3]

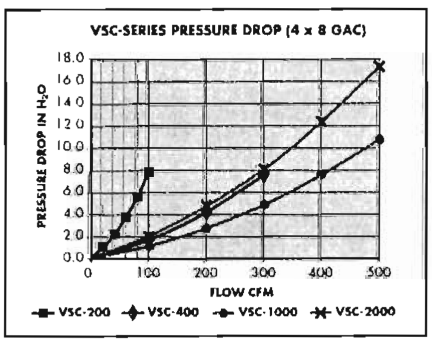
[1] Carbon steel and stainless steel internals are also available.
[2] For vacuum greater than 12 in. Hg on VSC-2000, contact your USFilter Westates representative.
[3] For vacuum service on VSC-3000 and VSC-8000, contact your USFilter Westates representative.
[4] For higher temperatures, stainless and carbon steel internals are available.
For detailed dimensional information or drawings, contact your local USFilter Westates sales representative.

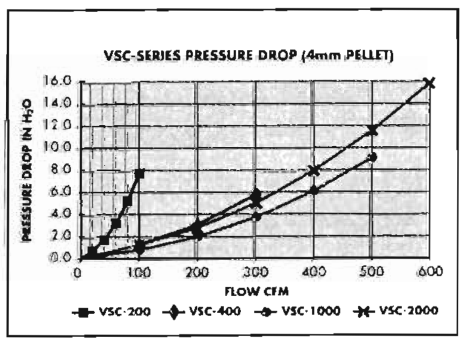
VSC-Series Adsorbers Safety Considerations

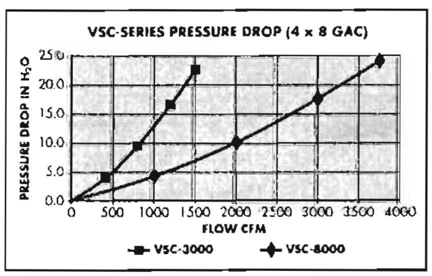
The adsorption of organic contaminants on activated carbon is an exothermic process, i.e. involves the release of heat.

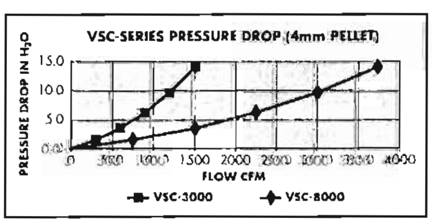
Certain chemical compounds such as ketones, aldehydes, organic acids and organic sulfur compounds may form reactive species on the carbon surface and under certain conditions may lead to a high temperature rise. If you are unaware or unsure of reactions that may occur, appropriate tests should be performed before installing the VSC.

At high VOC concentrations of organic compounds the heat of adsorption can lead to an increase in carbon bed temperature. The heat can be controlled by a number of techniques such as dilution of the inlet flow, nitrogen blanketing of the carbon system or prewetting of the carbon bed.









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Customer and
Technical Service Network:

Gulf Coast Region	800.659.1723
(Louisiana)	225.744.3153
Southwest Region	800.659.1771
Mid-Atlantic Region	800.659.1717
Midwest Region	708.345.7290
Northwest Region	800.659.1718
Southeast Region	225.744.3153
New England Region	800.659.1717

www.usfilter.com

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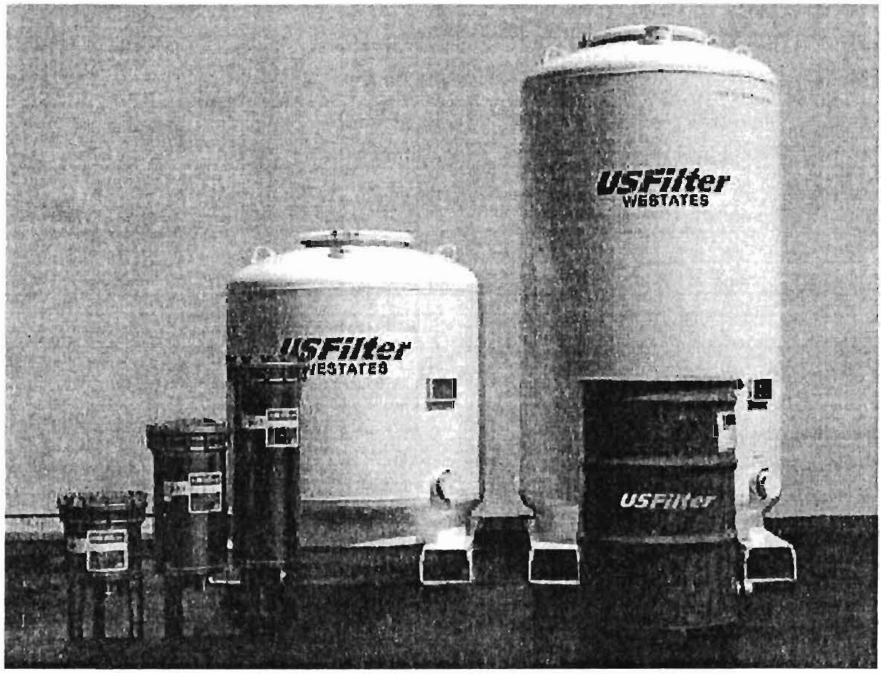
USFILTER WESTATES CARBON ASC-SERIES LOW PRESSURE LIQUID PHASE ADSORBERS

Benefits and Design Features

- *Rugged carbon steel construction; internally/ externally welded seams*
- *SSPC-SP5 surface preparation, fusion bonded epoxy internal lining; rust preventative/urethane exterior coat. (ASC-1000/2000)*
- *Approved for the transport of hazardous spent carbon*
- *ASC-1000/2000 can be easily moved with a forklift*
- *Adapters are available to reduce the inlet/outlet to 1" FNPT (ASC-2000) and 2" FNPT (ASC-1000/2000)*
- *Cartridge and bag prefilters available*
- *ASC-1000/2000's available for rental or purchase*

Piping Manifold (Optional)

- *2"/3" sch 80 PVC piping and valves (optional carbon steel and stainless steel piping)*
- *Series or parallel operation.*
- *Clean utility water connection for manual backflush.*
- *Sampling ports and pressure gauges*
- *Flexible hoses with Kamlock fittings allow easy installation and removal during service exchange operations.*



ASC-Series Adsorbers are designed to provide uniform water flow for consistent treatment and to ensure efficient carbon usage. The ASC-Series Adsorbers can be cost effectively used in applications including:

- Groundwater remediation
- Wastewater filtration
- Pilot testing
- Leachate treatment
- Dechlorination
- Spill cleanup

Installation, Start Up and Operation

The ASC-Series Adsorbers are shipped filled with dry activated carbon that must be properly wetted and deaerated prior to use.

Your USFilter sales representative can assist with details on installation, preferred operating conditions and carbon usage calculations using our extensive isotherm database.

At the time of purchase or rental of the ASC-Series Adsorbers, arrangements should be made for the reactivation of the spent carbon. USFilter Westates will provide instructions and assistance to obtain acceptance of RCRA or non-RCRA spent carbon for reactivation.

ASC-Series Adsorbers must be drained and the inlet/outlet plugged prior to shipment. Spent carbon cannot be received until the acceptance process has been completed.

USFilter

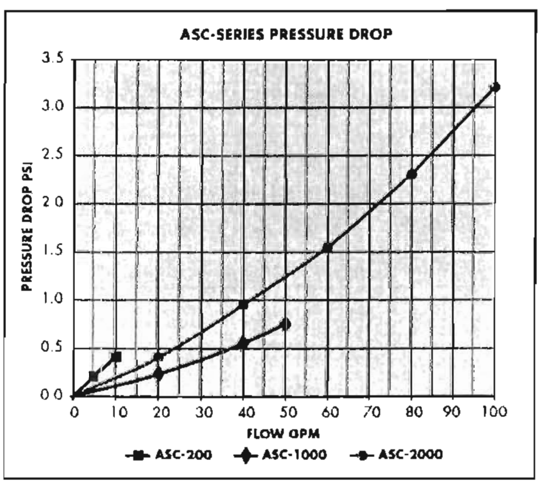
ASC-SERIES LOW PRESSURE LIQUID PHASE ADSORBERS

TO BE USED AT EVERETT
POWDER MILL GULCH SITE

SPECIFICATIONS

	ASC-200	ASC-1000	ASC-2000
Dimensions, diameter x overall height	22" x 34"	48" x 56"	48" x 96"
Vessel Construction	Carbon Steel	Carbon Steel	Carbon Steel
Inlet/Outlet Connection	2" FNPT/2"MNPT	4" FNPT	4" FNPT
Manway	Top	18"	16"
Internal Piping	PVC	PVC	PVC
Interior Coating	Epoxy	Fusion Bonded Epoxy	Fusion Bonded Epoxy
Exterior Coating	Enamel	Epoxy/Urethane	Epoxy/Urethane
Carbon Bed Volume (cu.ft.)	6.8	34	68
Cross Section (sq.ft.)	2.6	12.3	12.3
Vessel Weight (lbs.):			
Shipping (carbon)	250	1890	3190
Operating (approx)	500	4280	7250
Flow, gpm (max)	10	50	100
Pressure, psig (max)	3	25	25
Temperature °F. (max)	140°	140°	140°
Pounds of Carbon	200	1000	2000
Contact time @ max flow/min:	5.1	5.1	5.2
Backflush rates (GPM)	15	75	75

For detailed specifications or dimensional information or drawings, contact your local USFilter Westates sales representative



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Northwest Region	800.659.1718
Southeast Region	225.744.3153
New England Region	800.659.1717

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WS-AQSB-DS-0704

Voice Synthesized Monitoring and Control System
For Environmental and Operating Conditions

1 YEAR WARRANTY

MADE IN USA

OMEGAPHONE®

$395

YEAR 2000 COMPLIANT

- **Dials Multiple Phone Numbers to Deliver Alert Message**
- **Monitor Temperature, ac Power and High Level Sound**
- **Digital Inputs for Switch Closure Sensing**
- **Use with Standard Phone Equipment**
- **Temperature Input Range: -20 to 150°F**
- **Battery Backup**

OMA-P1104 4-alert desktop monitor, $395.

The OMA-P1104 provides cost effective monitoring and control of environmental and security conditions in industrial, office and residential locations. The OMA-P1104 desktop system has 4 input channels. Each input may be configured for either temperature measurement or contact closure sensing. The OMA-P1104 monitors ac power, temperature, high sound level (i.e., smoke/fire alarms), plus digital inputs for hook-up to switch closure sensors.

When an alarm condition occurs, the unit will automatically dial user-programmed phone numbers to deliver the alarm message, in English. It continues to call until the alert message is properly acknowledged. You can call the unit for a complete status report on monitored conditions. The unit also provides a live 'listen in' feature to monitor actual sounds on-site.

Specifications

Inputs:
All units monitor ac power, high level sound; OMA-P1104 has 4 inputs configurable as temperature/contact closure.

Temperature Input Range:
-20 to 150°F

Power:
105-124 Vac through class 2 transformer with 6 ft cord

Batteries:
Six 1.5 V alkaline batteries (not included), provides up to 12 hr continuous operation with ac power off;

Phone Connection:
Standard RJ11 phone jack; works with rotary or pulse dialing systems

Operating Ambient:
40 to 100°F, clean dry environment

Dimensions:
51 H x 196 W x 219 mm D (2" x 7.75" x 8.625")

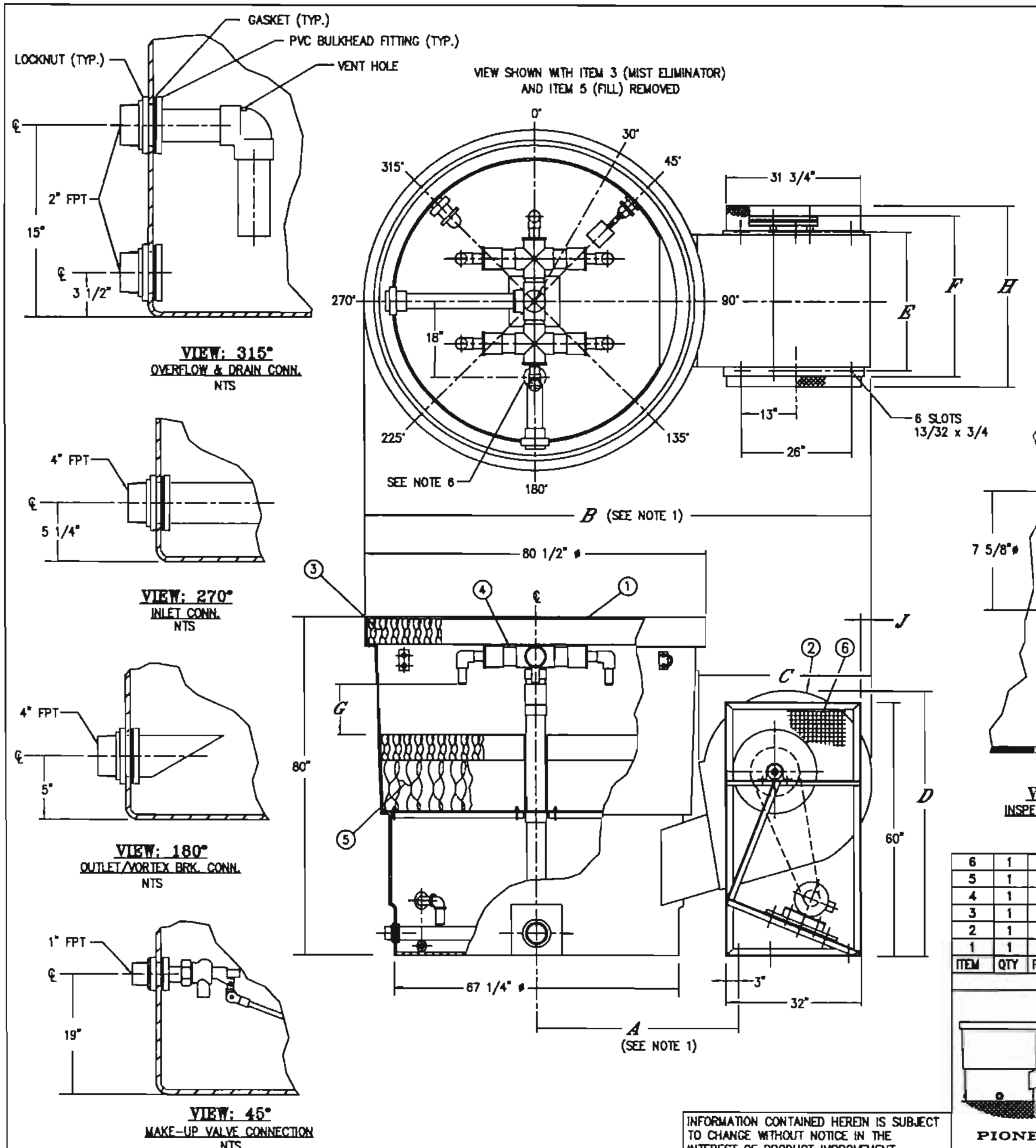
Weight:
0.91 kg (2 lb) with batteries

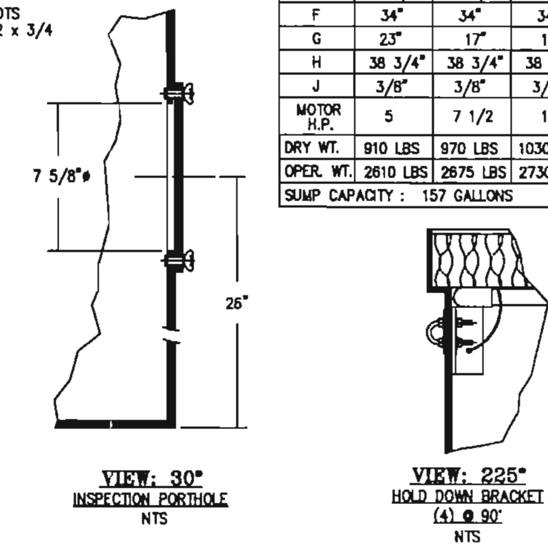
To Order *(Specify Model Number)*

Model Number	Price	Description
OMA-P1104	$395	4 alert input desktop monitor, includes one integral temperature sensor

Each unit supplied with complete operator's manual
Ordering Example: *OMA-P1104 four channel desktop monitor, $395*

G





DATE	SYM	REVISION	AUTH	CHK
11/2/98	A	REDRAWN IN CAD	BLO	W.P.
8/26/99	B	REV. INSPECT. PORT & MU	BLO	J.F.
12/12/00	C	ADDED NOTE 7	BLO	J.F.
3/7/01	D	MOVED OUTLET UP TO 5" FROM 4 5/8"	BLO	J.F.
3/13/02	E	REV. MAKE-UP SHAPE	BLO	O.D.

NOTES:

1. DIMENSIONS SHOWN ARE NOMINAL AND ARE SUBJECT TO FABRICATION TOLERANCES.
2. TOWER TO BE INSTALLED ON A FLAT AND RIGID SURFACE, PROPERLY SUPPORTED.
3. EXTERNAL PIPING MUST BE INDEPENDENTLY SUPPORTED.
4. PIPING & BULKHEAD FITTING MATERIAL IS PVC.
5. HARDWARE MATERIAL IS TYPE 304 STAINLESS STEEL.
6. BOTTOM OUTLET IS OPTIONAL IN LIEU OF SIDE OUTLET.
7. RISER PIPE HAS 1/4" WEEP HOLE IN SUMP.

UNIT	ΔT 50	ΔT 75	ΔT 100
A	44 3/8"	44 3/8"	44 3/8"
B	9'-6"	9'-6"	9'-6"
C	36 1/2"	36 1/2"	36 1/2"
D	60 1/2"	60 1/2"	60 1/2"
E	28 5/8"	28 5/8"	28 5/8"
F	34"	34"	34"
G	23"	17"	11"
H	38 3/4"	38 3/4"	38 3/4"
J	3/8"	3/8"	3/8"
MOTOR H.P.	5	7 1/2	10
DRY WT.	910 LBS	970 LBS	1030 LBS
OPER. WT.	2610 LBS	2675 LBS	2730 LBS
SUMP CAPACITY : 157 GALLONS			

ITEM	QTY	PART NO.	DESCRIPTION	MATERIAL	REMARKS
6	1		FAN GUARD	PVC COATED STEEL	
5	1		FILL	PVC	
4	1		SPRAY TREE ASSEMBLY	PVC	
3	1		MIST ELIMINATOR	PVC	
2	1		BLOWER ASSEMBLY	COATED STEEL	
1	1		TOWER SHELL	POLYETHYLENE	

BILL OF MATERIALS

INFORMATION CONTAINED HEREIN IS SUBJECT TO CHANGE WITHOUT NOTICE IN THE INTEREST OF PRODUCT IMPROVEMENT.

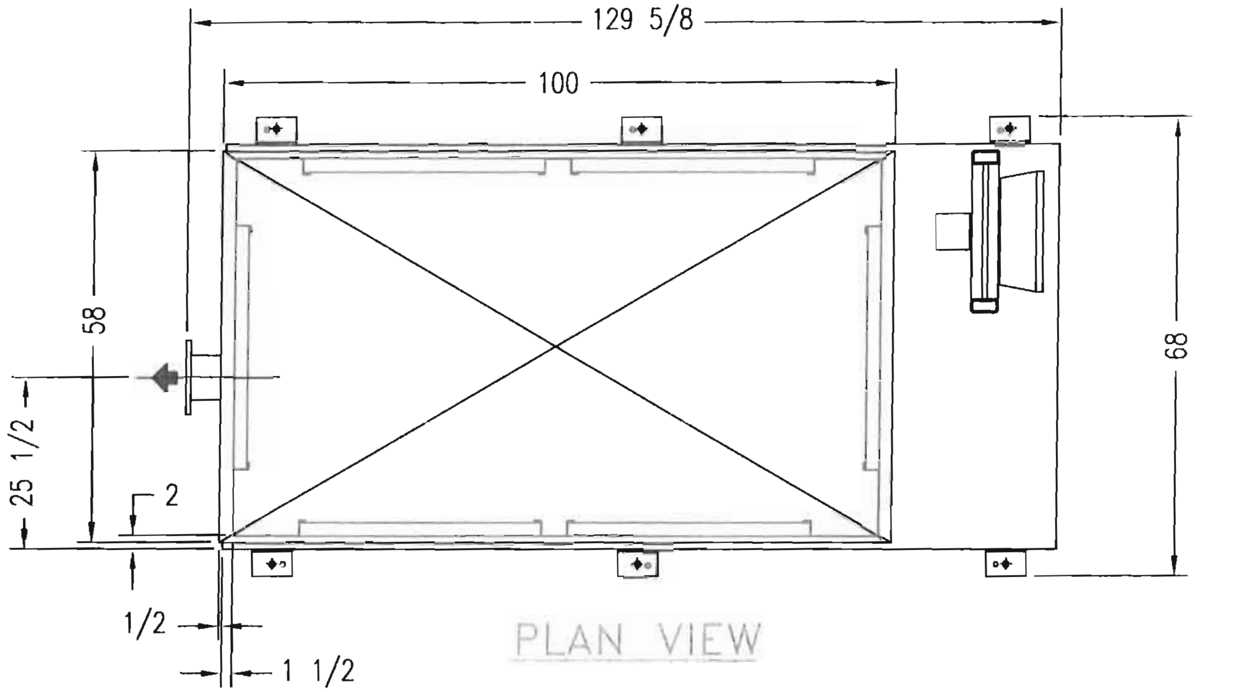
PIONEER®

DELTA COOLING TOWERS, INC.
41 PINE STREET, ROCKAWAY, NJ 07866
PH 973.586.2201 FAX 973.586.2243

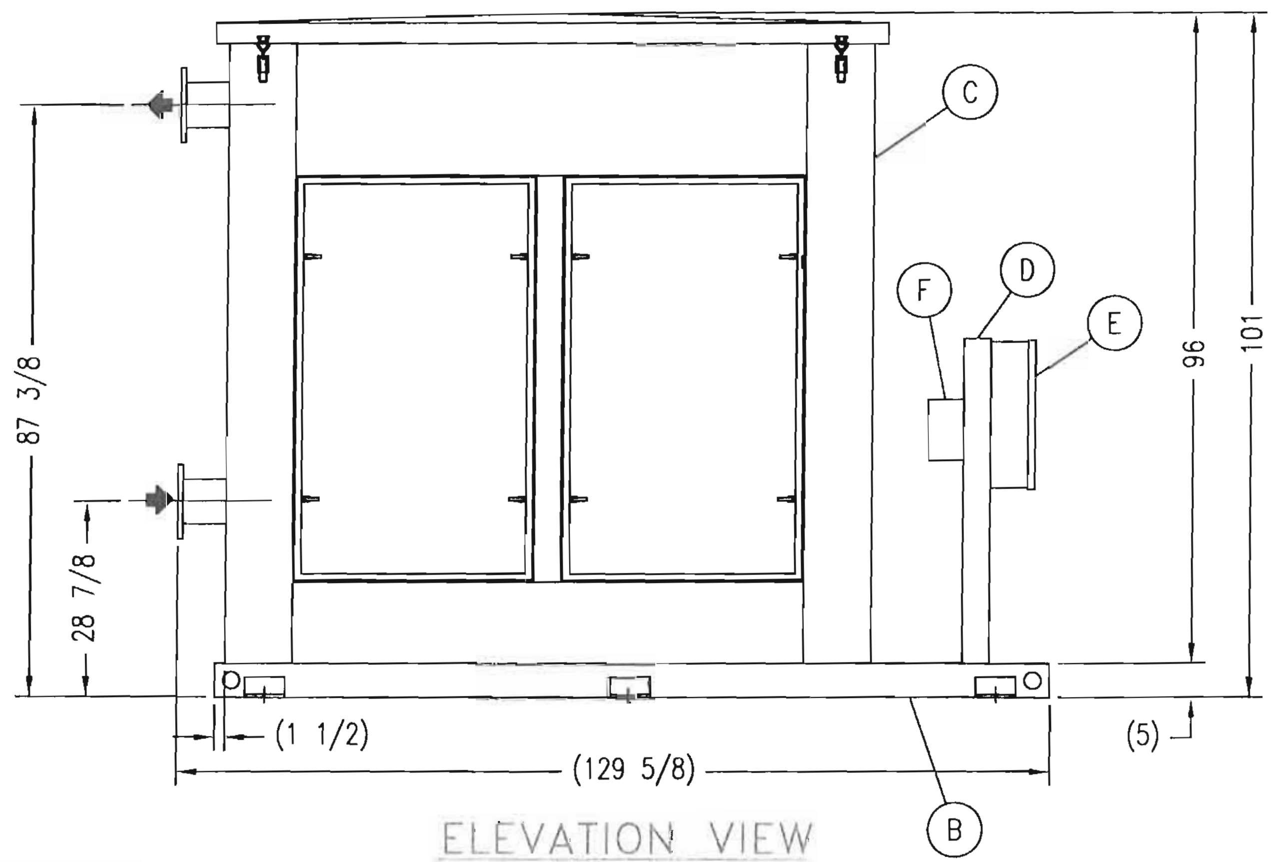
TITLE ΔT 50-100 ASSEMBLY

DWN BY Bonnie L. Odde
APPVD BY W.A. Patterson
JOB#
SCALE 3/4" = 1'-0"
DWG NO. DT-C-78-300
DATE 11/2/98

DRAWING NUMBER
BV063 A 0000



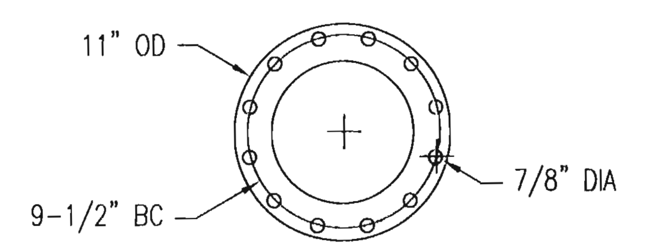
PLAN VIEW



ELEVATION VIEW

ITEM		DESCRIPTION
A		PACKAGE, VACUUM, 711 URAL, 40 HP
B		SKID, WELDMONT
C		ENCLOSURE ATTENUATION GALVANIZED
D		BRACKET, TWO PANEL SUPPORT
E		CONTROL PANEL NEMA 4X
F		TRANSFORMER, 1 KVA
G		FAN, AXIAL, 18", 1/4 HP
H		SPOOL PIECE, 6"X32" WELDMONT
J		SPOOL PIECE 6"X50.5" WELDMONT
K		BELT V, 5VX950
L		SHEAVE 2 GROOVE 5V 1030 SK
M		SHEAVE 2 GROOVE 5V 1090 SK
N		BUSHING, OD, SK, 2-1/8" BORE
P		BUSHING OD, SK, 1-5/16" BORE
R		TEMPERATURE GAUGE 50-500 DEG F
S		VACUUM GAUGE 30-0" HG
T		FILTER STD, F65-6V, VAC, INLINE, WIRE
W		FILTER, SOL, FS-230P-250, SIL, PAPER
Y		VALVE 2-1/2", GATE
AA		VLV, RELIEF, VAC, 2-1/2", SET @ 14" HGG

NOTES:
1. ALL DIMENSIONS ARE APPROXIMATE AND SUBJECT TO CHANGE.
2. CERTIFIED DRAWINGS AVAILABLE UPON REQUEST.
3. DIMENSIONS ARE IN INCHES, BRACKETED [] DIMENSIONS ARE MILLIMETERS.
4. UNLESS OTHERWISE NOTED, DIMENSIONS ARE ± 1/4".
5. CUSTOMER MUST SUPPORT OUTLET CONNECTION.



INLET & DISCHARGE FLANGE
6" ANSI FLANGE, 11/16" THICK

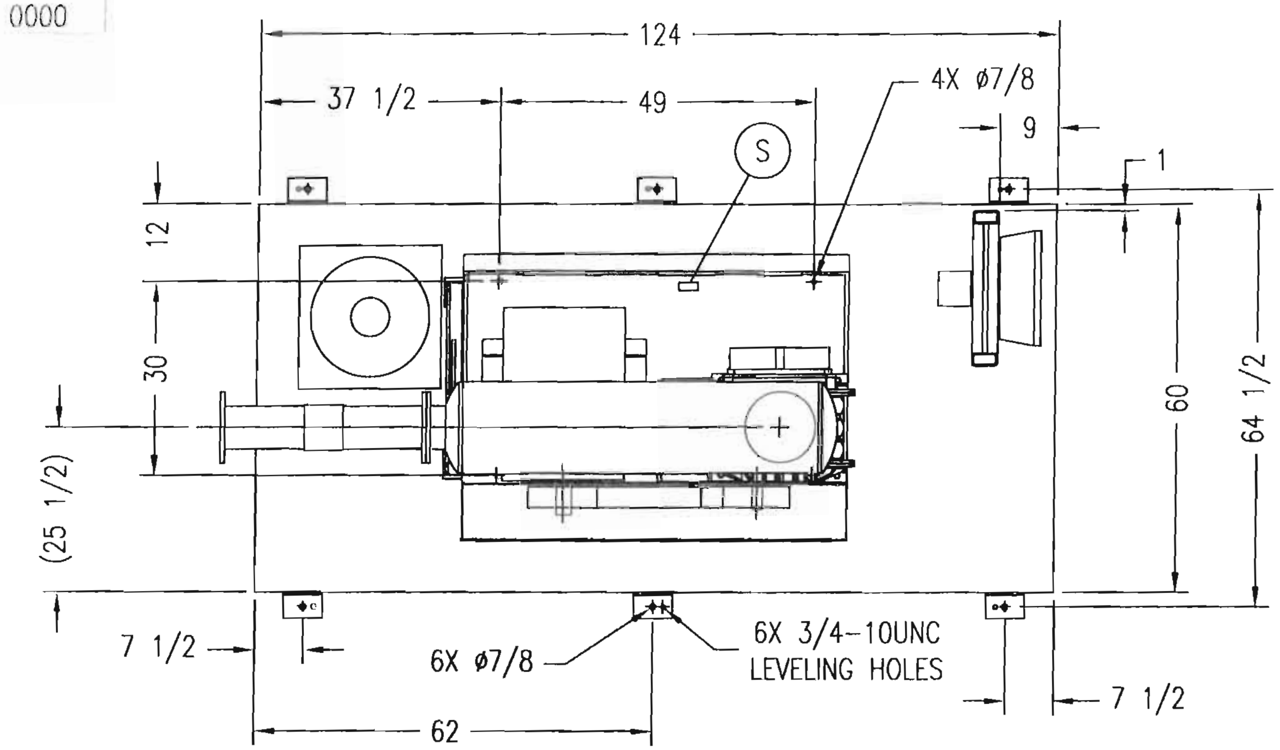
REV	DESCRIPTION	DATE	BY

REP INC.
ROTATING ENGINEERED PRODUCTS, INC.
2405 MURPHY BOULEVARD GAINESVILLE, GA 30504
TOLL FREE: (800) 536-9933, (770) 538-0020, FAX: (770) 538-0022

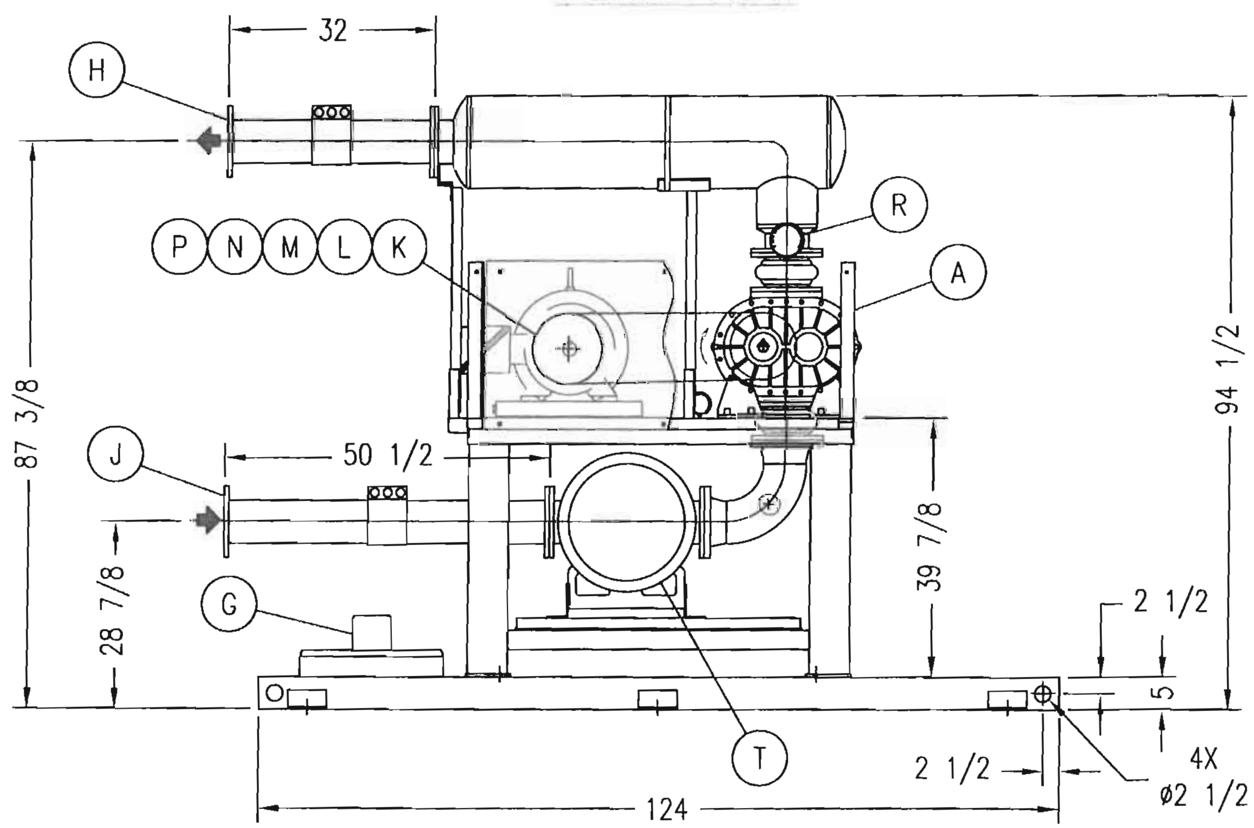
SCALE: NTS
DRAWN BY: BB DATE: 11-07-02
CHECKED BY: DATE:
APPD. BY: DATE:
TITLE: VACUUM BLOWER PACKAGE ROOTS 711 URAI, 40 HP 324T FR V4 CONIGURATION
MODEL/CUSTOMER
DRAWING NO. BV063 A 0000
SHEET NO. 1OF2
REV.

BOX IS BLUE IF ORIGINAL

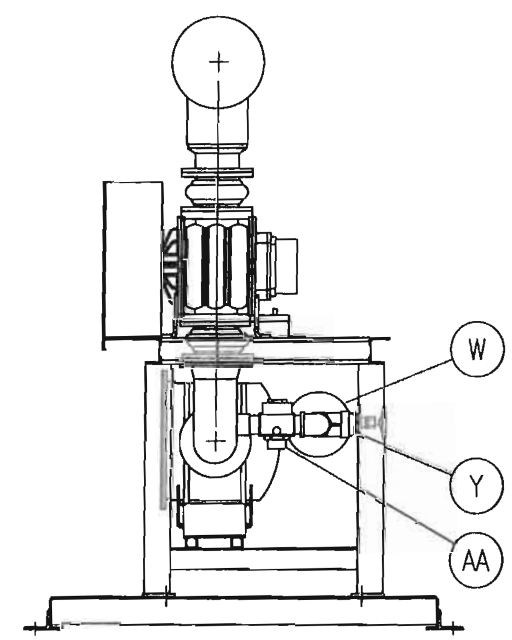
DRAWING NUMBER
BV063 A 0000



PLAN VIEW



ELEVATION VIEW



END VIEW

REV	DESCRIPTION	DATE	BY

REP INC.

ROTATING ENGINEERED PRODUCTS, INC.
2405 MURPHY BOULEVARD GAINESVILLE, GA. 30504
TOLL FREE: (800) 536-9933, (770) 538-0020, FAX: (770) 538-0022

SCALE: NTS		TITLE: VACUUM BLOWER PACKAGE ROOTS 711 URAI, 40 HP 324T FR V4 CONIGURATION	
DRAWN BY: BB	DATE: 11-07-02		
CHECKED BY:	DATE:		
APPD. BY:	DATE:	MODEL/CUSTOMER	DRAWING NO. BV063 A 0000 — SHEET NO. 2OF2 — REV.

BOX IS BLUE IF ORIGINAL

APPENDIX C

System Monitoring Plan

System Monitoring Plan

In Situ Thermal Remediation
(Electrical Resistance Heating)
Powder Mill Gulch Site
Everett, Washington 98204

THERMAL
REMEDIATION
services inc.

Prepared by

Thermal Remediation Services, Inc.
2325 Hudson Street
Longview, Washington 98632

TABLE OF CONTENTS

List of Tables

Abbreviations and Acronyms

bbb	Below Basin Bottom
CO	Contracting Officer
COC	Chain of Custody
CQCP	Contractor Quality Control Plan
DNAPL	Dense Nonaqueous Phase Liquid
DQOs	Data Quality Objectives
ERH	Electrical Resistance Heating
FSP	Field Sampling Plan
gpm	Gallons per Minute
HASP	Health and Safety Plan
ID	Identification
μg/kg	Micrograms per Kilogram
μg/L	Micrograms per Liter
$\mu g/m^3$	Micrograms per Cubic Meter
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
NAPL	Nonaqueous Phase Liquid
PMP	Performance Monitoring Plan
PPE	Personal Protective Equipment
ppm	Parts per Million
QC	Quality Control
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SSHO	Site Safety and Health Officer
TMP	Temperature Monitoring Point
TRS	Thermal Remediation Services
VOC	Volatile Organic Compound
VR	Vapor Recovery

1.0 INTRODUCTION

This System Monitoring Plan (SMP) has been prepared pursuant to and in accordance with specifications contained in contract 25175.006 between Landau Associates and Thermal Remediation Services (TRS) for In-Situ Thermal Remediation at the Powder Mill Gulch site, Everett, Washington.

The primary objective of the project is to remove VOCs from the subsurface in the defined ERH remediation area. This System Monitoring Plan provides guidance for collection of information/data relaying to the installation, operation, and evaluation of the ERH system at the Powder Mill Gulch site. This plan will document the methods and quantity of operations data which TRS will produce. Contract 25175.006 does not specify specific physical sampling tasks for TRS, therefore, this document provides sampling protocol recommendations for other Landau project personnel when sampling is required. Information concerning collection, shipping, chemical analysis, interpretation, and reporting for air, groundwater, wastewater, and solid waste samples will be provided elsewhere.

2.0 EQUIPMENT AND SITE MONITORING

TRS will confirm that all components of its system are working correctly and that power is being effectively applied to the treatment volume. Frequent monitoring of the subsurface temperatures and pressures in the treatment area as well as monitoring of the vapor treatment equipment will allow TRS to optimize the ERH application.

Performance monitoring will begin as construction starts. TRS closely monitors and records the installation of all below grade components. TRS will be on site during installation of its process equipment to oversee construction, and offer technical guidance as needed to other project members.

Once installation is complete and documented, TRS will perform system startup and testing for approximately one week. Once testing is complete, power application to the site will be continuous except for system adjustments, routine maintenance, and scheduled groundwater sampling events. Details and events associated with system start up and operations will be documented in the weekly operations report.

2.1. Power Application Monitoring

The application of power to the subsurface during ERH is very closely monitored and adjusted. Power application data is collected both manually and automatically with the data acquisition system. The ERH PCU system is fully capable of monitoring and recording all aspects of the ERH electrical application. The system operates on PC based programmable logic software giving operators both local and remote monitoring capabilities. The PC will be connected to either a telephone line or if available, a broadband Internet service will be installed in the ERH office.

2.2. Temperature Monitoring

As a means of monitoring the ERH process, TRS's equipment will be installed to provide continuous thermal data collection within the subsurface. Temperature data will be collected from 10 TMPs located inside the treatment area and 4 TMPs 10 feet outside of the treatment area. The 10 TMPs inside the treatment region will be constructed using 1 inch Schedule 40 stainless steel pipe and the 4 TMPS outside of the treatment region will be constructed of 1 inch Schedule 40 CPVC. Both sets of TMPs will be sealed at the top and bottom to prevent water intrusion. Each TMP will contain an embedded thermocouple monitoring string that will monitor 3-12 individual depth intervals in 5 foot increments. Internal monitoring will begin at 16 feet bbb and end at 72 feet bbb, while external monitoring will begin at 6 feet bbb, and end at 15 feet bbb. The thermocouples are ANSI type "T" and are sheathed with Teflon. The temperature strings are routed to the surface and terminated at data acquisition nodes on the site. These data acquisition nodes are connected to the PCU control computer via an optical fiber network. Data from these thermocouples will be monitored continuously and recorded once per day. The data will be imported into an Excel spreadsheet for easy manipulation and graphical display and reported on a weekly basis.

2.3. Condenser Monitoring

The ERH steam condenser is a key component in the vapor recovery stream. The ERH steam condenser is also continuously monitored to ensure uninterrupted operations and environmental compliance. The following table illustrates the data monitored and recorded from the ERH steam condenser.

Table 1: Condenser System Monitoring

Location	Units	Monitoring	Recording Frequency	Reporting Frequency
Inlet Vapor Temperature	Temperature °C	Daily	Daily	Weekly
Outlet Vapor Temperature	Temperature °C	Daily	Daily	Weekly
Vapor Flow Rate	scfm	Twice per Month	Twice per Month	Twice per Month
Extracted Water Total Volume	Gallons	Twice per Month	Twice per Month	Twice per Month
Drip Water Total Volume	Gallons	Twice per Month	Twice per Month	Twice per Month

2.4. Subsurface Vacuum Monitoring

In order to achieve confidence of vapor recovery, the vapor recovery system will be designed to produce a minimum vacuum of 0.1 inch of water at all points located 10 feet beyond the remediation area. With the existing site data, TRS believes a vacuum of 0.1 inch of water can be maintained in the vadose zone immediately surrounding the remediation area, and will design for that minimum vacuum.

As a means of monitoring the subsurface vacuum in and adjacent to the ERH area, TRS will install 4 subsurface vacuum monitoring points 10 feet outside the treatment area. Each external vacuum monitoring point will be constructed using 1.25-inch Schedule 40 CPVC pipe and will be screened for vacuum measurements between 10 and 15 feet bbb. Each vacuum monitoring point will be fitted with compression fitting linked to PEX tubing. The length of tubing will be adjusted to prevent it from being submerged by the typical 8 feet of standing water in the basin. The drip system piping will be used to monitor the vacuum influence at individual electrodes as necessary. The PEX drip tubes will be connected to a manifold above the 8 foot water mark for easy vacuum measurement. Data from the 4 external vacuum monitoring points will be collected twice per month, and data from the VR vacuum monitoring points will be collected as needed. The data will be transferred twice per month to an Excel spreadsheet for easy manipulation and graphical display and reported twice per month.

2.5. Methods of Monitoring

During operations, TRS will monitor the system remotely, via telephone service, and will provide weekly updates to Landau via electronic letter reports. These reports will describe the general operations of the ERH system; work performed during the previous week, and anticipated upcoming work. The reports will also contain data on the subsurface temperature profile, power used by the entire remediation system and energy input to the subsurface. These reports will allow all involved parties to quickly understand the progress that is being made towards the remediation goals.

TRS will provide weekly site visits for visual inspection and maintenance of the ERH components of the system. Near the end of the remediation, TRS might reduce the site visit frequency to once every two weeks. Additional trips will be made as necessary to ensure the ERH system is functioning efficiently and effectively.

Table 2 describes the scheduled Operations & Monitoring items that will be required during the ERH remediation

Table 2. System Operations and Monitoring Schedule

Operation/Maintenance Item	Performance Schedule	Performed By
Subsurface Temperatures	Daily	TRS
ERH Voltage, Current, and Power	Daily	TRS
Energy Input	Daily	TRS
Vapor Stream VOC Sample &Analysis	Weekly/Twice per Month	Landau
Condensate VOC Sample &Analysis	Twice per Month/Weekly	Landau
Liquid Granular Activated Carbon VOC Analysis	Twice per Month/Weekly	Landau
Vapor Granular Activated Carbon VOC Analysis	Twice per Month/Weekly	Landau
Applied Vacuum	Twice per Month/During Vapor Sampling	TRS/Landau
Total VR System Airflow	Twice per Month/During Vapor Sampling	TRS/Landau
Individual Electrode Currents	Twice per Month/per site visit	TRS
ERH Equipment Inspection	Twice per Month/per site visit	TRS
Blower Greasing/Oil Change	operating hours	TRS
Filter/Strainer Clean and Inspect	Twice per Month/per site visit	TRS/Landau

2.6. Vapor Recovery Samples

TRS recommends a process vapor sample be collected each week and analyzed for VOCs. This sample will provide part of the basis for determining mass removal during the project. The sample results will also help determine the relative progress of the ERH process by evaluating the concentration trends of the sample versus operating time. The vapor sample should be collected after the condenser and prior to vapor treatment. The sample analysis should follow the EPA TO-14 method. Sampling procedures are listed in section 4.

2.7. Effluent Monitoring

TRS also recommends sampling of the effluent from both the vapor granular activated carbon (GAC), and from the liquid GAC. The purpose of this sampling will be to determine the effectiveness of the GAC treatment, and of the need for GAC replacement. Samples will be collected from the sample ports placed between the in-series GAC vessels. Samples from both the liquid (condensate) and vapor GAC treatment systems should be taken twice per month. Sampling frequency should be increased if the rate of GAC usage in the vapor stream is more than1000 lbs/week or if usage in the liquid stream is more than 250 lbs/week. Samples for the liquid GAC should follow the procedure listed in Section 4.1 of this document and be analyzed using the EPA 8260 method. Vapor samples should be collected using the vacuum sampling procedure listed in Section 4.2 of this document, and analysis should follow the TO-14 method.

3.0 DOCUMENTATION

3.1. Reporting

To provide near real-time reporting and to minimize paper generation, data gathered during the operation of the ERH system will be reported in a weekly operations report as required by the contract specifications. All information will be maintained in a database and reported to the Powder Mill Gulch project team members.

Landau Associates will provide TRS with electronic files and hard copies of all collected and analyzed data upon request. These documents will better allow TRS to make adjustments to their system to optimize power application and vapor recovery. Landau will be responsible for informing TRS of when contract requirements for TCE concentration have been achieved. This will signal the end of power application from the TRS system.

3.2. Field Data Management

Proper procedures in field sampling should insure project decisions are based on accurate data. Field sampling assignments will be coordinated by the Landau Associates Site Manager and the Project Manager in conjunction with input from TRS. Landau Associates is responsible for providing the appropriate equipment and data forms to accompany the task, and will collect the data forms at the completion of the task or day. The forms should be up-to-date with respect to samples to be collected, sample IDs, QA/QC sample collection requirements and where the samples are to be turned in for analysis. A copy of the completed data forms will be supplied to the appropriate project staff by Landau Associates. Originals will be filed appropriately.

3.3. Data Verification, Validation, and Assessment

Data verification of data collected by TRS will be accomplished by a combination of computer-based data verification and review by experienced TRS personnel.

4.0 SAMPLING PROCEDURES

4.1. Condensate Sampling Procedure

The following standard operating procedures (SOPs) will be used for the sampling of recovered vapors and for condensate flows.

Purpose:

Condensate samples are collected from remediation system liquid streams for analysis of chemical parameters using an off-site lab. Condensate sampling will require only sample containers and a 5 gallon bucket.

Sampling Procedure:

1. Place a 5 gallon bucket beneath the sampling port.

2. Open sampling port and purge the volume contained inside the piping of the port. The purge volume should be approximately 150 mL.

3. Open the sampling valve until the flow rate is approximately 150 mL/min.

2. Place the sample container under the flowing stream until the container is full.

4. Close the lid of the sample container and place in ice for shipment.

4.2. Vapor Sampling Procedure

The following standard operating procedures (SOPs) will be used for the sampling of recovered vapors.

Purpose:

Vapor samples are collected from the remediation system air streams for analysis of chemical parameters using analysis by an off-site lab. Vapor sample sampling systems will be vacuum leak tested and purged using a vacuum pump.

Equipment List:

1. Vapor Sampling Field Form and field logbook with indelible pens

2. Vacuum pump

3. 12 V battery or generator

4. Tedlar bags

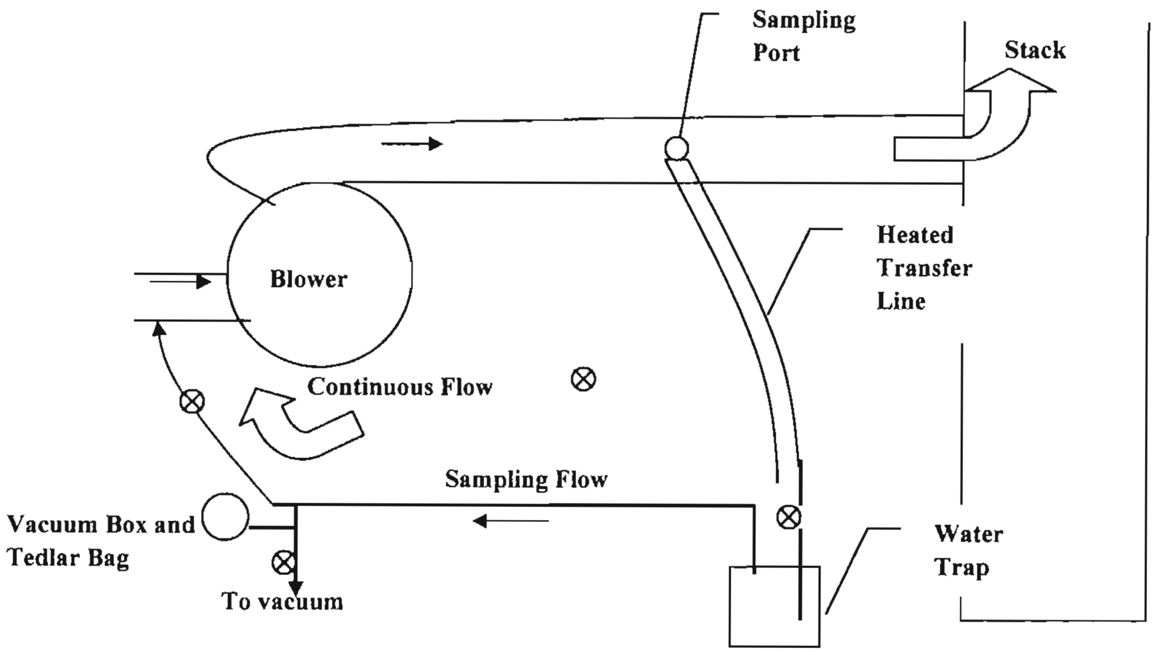
5. Site map and Site health and safety plan (HASP), if applicable

6. PPE appropriate for Site (see HASP if applicable)

Sampling Stacks and Flowing Streams at Near Atmospheric Pressure

For hot sampling, a continuous-flow, heated sampling line with water knock-out is necessary. See Figure 1. The system needs to be shown to be free from leaks prior to sampling each time. Make sure the port is situated on the pressure side of the blower.

Figure 1 Continuous-Flow Heated Sampling Line



Sampling Procedure:

1. Open the two flow system valves and allow system to flush for a minute, then initiate the Tedlar sample.
2. To initiate sampling, connect the Tedlar bag to the sample line inside of the vacuum box.
3. Seal the box
4. Pull a vacuum on the Tedlar bag and shut off the flow from the header and then the vacuum. Watch the Tedlar bag for evidence of a leak.
5. Once sure of no leaks, again pull a vacuum on the bag and release to flush the lines. Do the flush twice.
6. Once again apply vacuum and fill the bag, shutting off vacuum before the bag pops.
7. Shut the valve to the header and the vacuum.
8. Pinch off the sample line entering the vacuum box. Open the 3 way valve on the vacuum box to bring it to atmospheric pressure.
9. Remove the lid of the vacuum box, and close the valve on the Tedlar bag.
10. Record the date, time, and location on the field data sheet. Make any notes regarding sample location that will potentially influence the VOC sample collection.
11. Measure and record temperature, barometric pressure, wind speed, wind direction, and humidity. Record the general weather conditions such as percent cloud cover and precipitation. Note if there has been precipitation during the last 12 hours.
12. Attach the completed sample label to the tedlar bag and record the sample information on the chain of custody.
13. After the sample has been taken, the Tedlar bags should be kept cool and out of direct sunlight, a good container is a cooler.

14. Samples should be analyzed within 24 to 48 hours of the time of collection.

Grab Samples from Hot Flowing Streams at High Vacuum

For hot sampling, a continuous-flow, heated sampling line with water trap is necessary. See Figure 2. The system needs to be shown to be free from leaks prior to sampling each time.

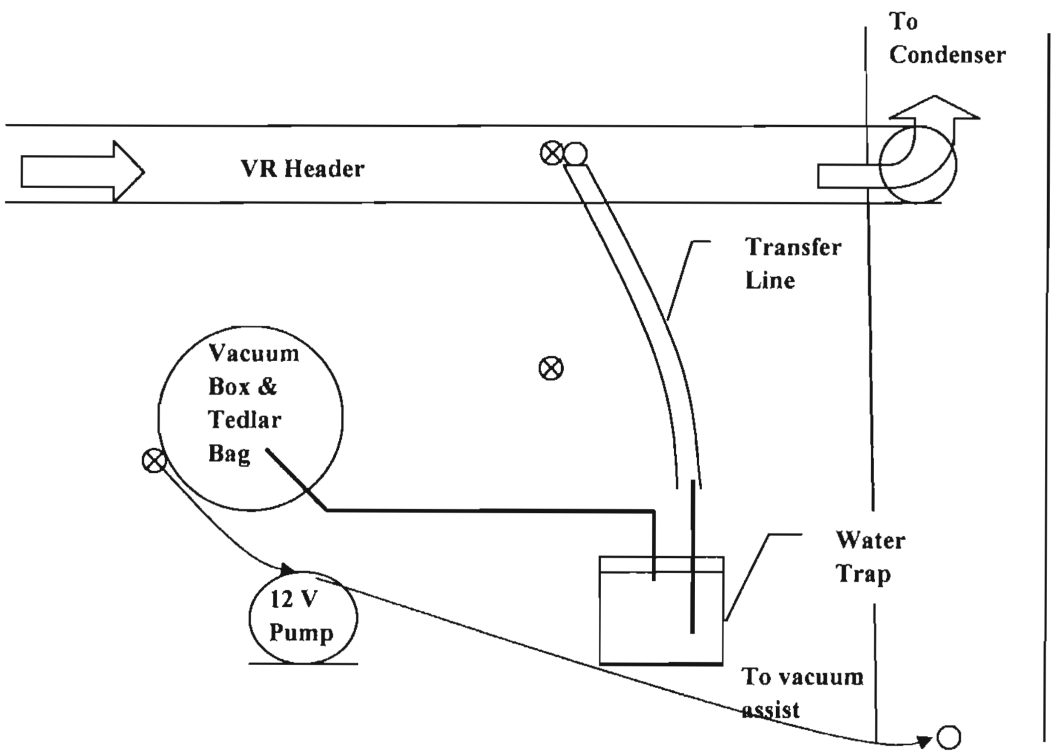


Figure 2. VR Vacuum Sampling Port

APPENDIX D

Performance Sampling Procedures

Performance Sampling Procedure

In Situ Thermal Remediation
(Electrical Resistance Heating)
Powder Mill Gulch Site
Everett, Washington 98204

THERMAL
REMEDIATION
services inc.

Prepared by

Thermal Remediation Services, Inc.
2325 Hudson Street
Longview, Washington 98632

GROUNDWATER SAMPLING PROCEDURES

Low-flow sampling and purging techniques are used in an effort to collect the most representative samples and to reduce the production of investigation-derived waste.

The apparatus used to perform sample cooling is shown in Figure 2 below.

Prior to initial sampling, a cooling coil is formed by wrapping a 10-ft length of ¼-inch stainless steel tubing around a 4-inch diameter pipe until 6 full turns have been made. The ends of the tubing are fashioned such that both ends of the tubing extend upward, as shown in Figure 1.

1. Telephone the TRS operator the day prior to sampling to schedule a remote shutdown. A shutdown period of at least 12 hours is preferred prior to groundwater sampling.

2. Lock-out and tag-out the ERH PCU. Note: this procedure can only be completed by personnel who have been trained and certified by TRS in lock-out and tag-out procedures.

3. Connect ¼-inch sample tubing to the cooling coil and place the coil in a bucket or cooler with ice to form the ice bath.

4. Water will be brought to the well head using a submersible bladder pump.

5. Purge the well at an initial rate of 1 liter per minute until the field indicator parameters (see Step 6) stabilize and the minimum purge volume is removed. The minimum purge volume is two times the static saturated well volume. The equation to calculate the minimum purge volume is:

   $$V = 7.48 \times r_w^2 (td-dg)$$

   Where V = one purge volume in gallons; r_w = radius of well casing in feet; td = total depth of well in feet; dg = typical depth to groundwater in feet.

6. The pumping rate is recorded on purge data sheets every 3 to 5 minutes during purging. Any adjustments to the pumping rate are recorded. Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (i.e., 0.1 to 0.2 liter per minute) to ensure stabilization of parameters. Adjustments to the pumping rate are best made within the first 15 minutes of purging to minimize purging time.

7. At the initiation of well purging and during the purging effort, water quality parameters including turbidity, specific conductance, pH and dissolved oxygen (DO) are measured with a Horiba (or equivalent) meter with flow cell. Readings are recorded on the purge data sheets every 3 to 5 minutes. Field parameters are monitored until stabilization occurs. Stabilization is complete when three consecutive readings are within the following criteria:

Specific conductance and DO readings within 10 percent

pH within +/-0.2 standards units

Turbidity at 10 NTUs or less

8. After the minimum purge volume is purged and all water quality parameters have stabilized, sampling may begin. If all parameters have stabilized, but turbidity remains above 10 NTUs, decrease the pump rate and continue monitoring. If the pump rate cannot be reduced and turbidity remains above 10 NTUs, the information will be recorded and sampling begun. For low yield wells, sampling commences as soon as the well has recovered sufficiently to collect the appropriate volume for the anticipated samples.

9. VOCs are collected first utilizing the following method: a column of water is drawn in the cooling coil tubing with the pump; the well sample valve and the bladder pump inlet valve are closed and the pump shut off; the cooling coil is disconnected from the well sample valve; the cooling coil is carefully removed from the ice bath; the pump inlet valve is opened; the sample is decanted into the sample vials from the pump end of the tubing via gravity flow. The process is repeated until the sample volume is collected.

10. Any other sample fractions (cations, anions) are sampled from the well end of the cooling coil tubing.

11. Groundwater samples including quality control (QC) samples are labeled, preserved and shipped per the Clients Sampling and Analysis Plan.

Groundwater samples are submitted to an outside laboratory for analysis. It is anticipated that one groundwater sample per well plus the associated QC samples are collected and submitted to the laboratory for analysis.

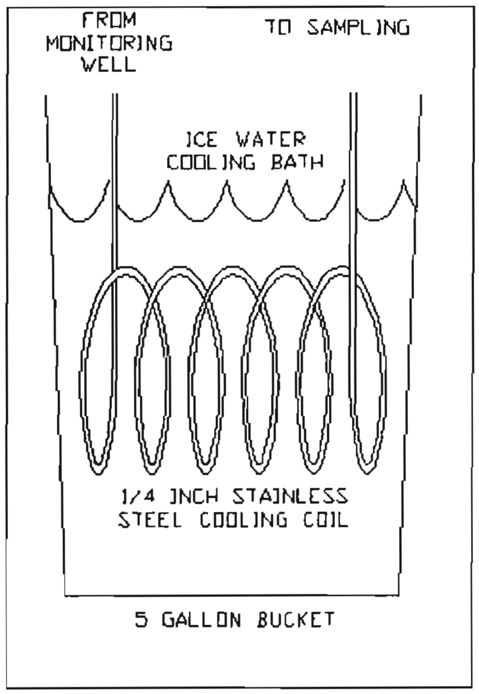


Figure 1. Sample Cooling Apparatus

APPENDIX E

Construction Quality Control Plan

Contractor Quality Control Plan

In Situ Thermal Remediation
(Electrical Resistance Heating)

Powder Mill Gulch Site
Everett, Washington

THERMAL REMEDIATION services inc.

Prepared by

Thermal Remediation Services, Inc.
2325 Hudson Street
Longview, Washington 98632

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Abbreviations and Acronyms

ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CM	Contract Manager
COR	Contracting Officer Representative
CQC	Contractor Quality Control
CQCP	Contractor Quality Control Plan
DNAPL	Dense Nonaqueous Phase Liquid
ERH	Electrical Resistance Heating
ESHM	Environmental Safety and Health Manager
FSP	Field Sampling Plan
NAPL	Nonaqueous Phase Liquid
OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethane
PCU	Power Control Unit
PID	Photoionization Detector
PM	Project Manager
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
SAP	Sampling and Analysis Plan
SSHO	Site Safety and Health Officer
TCE	Trichloroethene
Landau	Landau Associates, Inc.
TRS	Thermal Remediation Services
USEPA	U.S. Environmental Protection Agency
WMP	Waste Management Plan

1.0 INTRODUCTION

1.1 Corporate Commitment

TRS is committed to providing services of the highest quality while at the same time giving due consideration to project budgets, schedules, Landau and local program requirements.

TRS will take appropriate measures to ensure that quality factors are considered equally with regulatory codes, professional standards of practice, and contractually imposed requirements during each phase of design, engineering, construction, and operation.

1.2 Goals

The goal of the QA/QC Plan is to ensure that overall project management is maintained, production and quality are in compliance with contract requirements, and deficiencies are identified and corrected in a timely manner.

1.3 Objectives

The project QC management system is intended to meet the following objectives:

- Complete the ERH project to meet the contract specifications within the defined budget and according to approved plans
- Comply with regulatory agencies and health and safety requirements
- Provide a quality product in accordance with Landau, regulatory and local quality standards

1.4 Implementation of a Quality System for Environmental Measurements

Implementation of the quality system for this project requires an appropriate organizational structure and a feedback system covering the following key processes:

- Understanding Landau contract specifications and regulatory requirements
- Ensuring the assignment of qualified staff and subcontractors, including on- and off-site laboratories
- Establishing authority and personal responsibility for tasks, cost, and timeliness
- Ensuring that corporate capability and capacity are in alignment with the project scope
- Creating a communication system for review and feedback

- Providing independent review, follow up, and correction
- Documenting the quality process

2.0 MAJOR SITE TASKS AND OPERATIONS

The following is a list of anticipated major site tasks and operations to be performed:

- Mobilization and demobilization of equipment and temporary structures
- Install electrodes and subsurface monitoring equipment in the treatment area.
- Operate and monitor the ERH processes
- Manage and dispose of collected contaminant waste derived during ERH drilling activities

2.1 Definable Features of *In-Situ* Thermal Remediation Activities

The definable features of work for the remediation of contaminated soils are described in the following sections.

2.1.1 Reporting

To provide timely reporting, data gathered during the operation of the ERH system will be reported in a weekly operations report submitted to Landau.

Due to the number of temperature monitoring points and other data associated with the ERH system's power control unit, data will be maintained in a TRS computer which is also used for remote monitoring and control.

2.1.2 Installation of Electrodes and Subsurface Monitoring Equipment

A licensed survey team will document the perimeter of the treatment areas and the pre-construction and as-built grades prior to installing the electrodes at the treatment area.

A licensed survey team will mark the pre-determined grid within the treatment area to indicate where the electrodes will be installed within the treatment area. A licensed driller, to be contracted by Landau, will complete borings to a prescribed depth to accommodate placement of the subsurface ERH components which include 50 electrodes and associated subsurface monitoring equipment within the treatment area. Figures for the treatment area showing the plot plans, as well as figures indicating the construction design for all the subsurface components are located in the Work Plan.

Each ERH component will documented on as-built drawings. The as-built drawings will be completed, approved and distributed prior to initiation of ERH system start up.

All vapor recovery piping will need to be pressure tested before power is applied to the electrode field. The piping will be pressure tested by closing off the ball valves at each electrode and filling the piping with water. The water will then be pressurized to approximately 10 psi. Once pressurized, pressure readings will be taken every 5 minutes for 45 minutes. If the pressure has not dropped more than 1 psi in 45 minutes, no significant leaks exist. During pressure testing all piping should be visually inspected for leaks.

After piping has been pressure tested. TRS will apply about 50 volts to the on-service ERH electrodes. The induced voltage will be measured at hundreds of locations on the border of the exclusion zone. Locations with voltages in excess of one volt will be logged and noted on a plot plan. TRS will recheck all accessible locations periodically during ERH operation, especially when on-service electrodes change or when significant applied voltage increases are planned. TRS policy will not allow a step-and-touch potential greater than 15 volts at any point outside of the exclusion zone. Following voltage checks, the voltage on the electrodes will be increased to allow full power ERH operations. Once testing is complete, power application to the site will be continuous except for system adjustments, routine maintenance, and scheduled groundwater sampling events.

Operate, Monitor, and Sample ERH System

Once the ERH system is constructed and the final configuration approved by Landau, TRS will provide the labor and expertise to operate and maintain the ERH system. The PCU, energized power lines, and electrodes will be monitored and maintained by experienced professionals familiar with the ERH system. System status, operating times, and maintenance procedures will be documented in the weekly report.

Groundwater and condensed steam extracted from the ERH system will be sampled and analyzed at regular intervals and from prescribed sample locations by Landau.

2.1.3 Treat Vapor and Extracted Liquid

Vapor collected from the ERH system will be routed through a steam condenser, processed through a granular activated carbon (GAC) bed, and then discharged to the atmosphere. Landau will be responsible for the removal and replacement of spent activated carbon as needed. Air emissions will be controlled in accordance to the regulations and requirements of Boeing's existing Ecology Air Operations permit for the BCA Everett Plant. Condensate developed as a result of operating the condenser will be routed through a liquid activated carbon bed and then routed to the sanitary sewer system. Landau will be responsible for the removal and replacement of spent activated carbon as needed. The need for replacement of activated carbon will be based on sampling results obtained twice per month. These samples will be taken between in-series GAC vessels.

3.0 PROJECT ORGANIZATION

TRS has established an organizational structure to provide overall technical and administrative management control to accomplish specified project tasks and related quality objectives. This organizational structure assures that project objectives are defined and that competent team members have been assigned responsibility for performing the work. The project organizational chart is shown in Appendix A.

3.1 Contract Manager – Mr. Michael Dodson

Responsibilities: The CM reports to the COR and is responsible for administrative and technical aspects of the project. The CM determines the technical and quality requirements of the project and assures these requirements are met. The CM maintains the administrative and accounting interface with the client to resolve questions regarding invoicing and quality performance.

Qualifications: Mr. Dodson has managed over 300 projects during his 22 years in the environmental industry, most of them in the Pacific Northwest. His areas of technical expertise include soil physics, geochemistry, site investigation, and remediation system design. Mr. Dodson has 17 years of direct site remediation experience including the use of soil vapor extraction, bioventing, air sparging, MPE, pneumatic soil fracturing, chemical oxidation, bioremediation, and ERSH systems. He has working knowledge of applicable Federal, State and local laws, regulations, and guidance that will be involved in this project. Mr. Dodson has extensive experience with the regulatory requirements of the Washington State Department of Ecology and with the Puget Sound Air Pollution Control Agency permitting process.

3.2 Project Manager – Mr. Paul Bianco

Responsibilities: The PM reports to the CM and the COR and is responsible for administrative and technical aspects of the project. The PM determines the technical, schedule, and quality requirements of the project and assures these requirements are met. The PM maintains the administrative and technical interface with the client to resolve questions regarding technical and quality performance.

Qualifications: Mr. Bianco provides project management on TRS ERH projects from our regional office located in Bend, OR. Mr. Bianco received his B.S. in Bioenvironmental Engineering and his B.S. in Environmental Science from Rutgers University in 1994. He is a licensed Professional Engineer in Washington. Mr. Bianco has over 10 years of engineering and project management experience involved in the development, design, construction and operations of innovative *in situ* remediation technologies including ERH.

3.3 Operations Director – Jerry Wolf

Responsibilities: The TRS Operations Director is responsible for all work performed to achieve the desired results of the contract specifications. The Operations Director is responsible for the overall remediation activities at the site. Mr. Jerry Wolf, TRS founder and Vice President of Operations, has the experience, responsibility, and authority to direct all work performed for this operations phase of this project. He will be responsible for providing technical support and to ensure that the management and execution of all site activities are in exact accordance with the approved remedy, approved work plans, and all Federal, State and local laws and regulations.

Qualifications: Mr. Wolf has received extensive training and experience with electrical distribution and controls while serving in the U.S. Navy Nuclear Submarine Program from 1982 -1990. Mr. Wolf has over 19 years of experience in electrical systems design, installation, and operations. He is also an expert in the remediation technologies that support ERH, including soil vapor extraction, MPE systems, air sparging, bioremediation, steam condensing, and catalytic and thermal oxidization. Mr. Wolf has 17 years of experience as a site superintendent in the field of *in-situ* remediation. Mr. Wolf has been the operations manager and site superintendent on 10 *in-situ* thermal remediation projects using ERH since 1998.

3.4 CQC System Manager – Thomas Powell

Responsibilities: The CQC System Manager is responsible for overall management of CQC and has the authority to act in all CQC matters for the Contractor. Mr. Powell will be onsite or immediately available during remedial action activities. Mr. Powell has completed and has a current certification for the USACE "Construction Quality Management for Contractors" program. The CQC manager's first priority will be implementing the project CQC program, but he may be assigned other duties upon approval of the COR.

Qualifications: Mr. Powell has over 10 years of experience in the design, installation, operations and maintenance of *in-situ* thermal remediation systems including ERH and soil vitrification. While with Battelle Northwest Laboratories, he led the initial field demonstrations of ERH at a site near Niagara Falls, New York, Dover Air Force Base, a site in Chicago, IL, and at projects in Anchorage and Fairbanks, Alaska. Mr. Powell's areas of expertise include all aspects of electrical distribution and control, instrumentation, QC, and system configuration management. Mr. Powell has extensive experience characterizing off-gas effluent resulting from thermal treatment applications. Mr. Powell also has extensive experience handling both hazardous and radioactive wastes and the procedures associated with conducting projects at government facilities. As a PM, Mr. Powell was directly responsible for the successful application of ERH for to achieve 99% reduction of TCE DNAPL at a remediation project in Portland, Oregon.

3.5 Project Engineer – Greg Beyke, P.E.

Responsibilities: The Project Engineer shall ensure that all treatment related goals of the contract specifications are attained. He will be responsible for the design and overall quality of the *in-situ* thermal remedy.

Qualifications: Mr. Greg Beyke, P.E., TRS vice president of engineering, will lead our design engineering team. Mr. Beyke received his B.S. and M.S. in Aerospace Engineering from the U.S. Naval Academy and the University of Maryland in 1985 and 1986, respectively. Mr. Beyke provides design engineering for all TRS ERH remediations from our regional office located in Franklin, TN.

Mr. Beyke is a licensed Professional Engineer in Washington, Georgia, and Kentucky. As a founder of TRS Mr. Beyke is responsible for leading the engineering of ERH remediation systems as well as new technology development. He is the design engineer for the ERH and MPE remediation project at the EGDY at Ft. Lewis, WA. His responsibilities also include providing operations management and direction as well as research and development for the further commercialization of ERH. With over 18 years of engineering experience, Mr. Beyke is a recognized expert in the development, design and deployment of innovative *in situ* remediation technologies including ERH.

As a member of the *In Situ* Thermal Treatment Advisory Panel (ITTAP), Mr. Beyke has worked with experts from the USEPA, academia and the USACE to evaluate and rate the effectiveness of thermal technologies to treat a wide range of environmental remediation challenges on EPA managed sites. In addition, Mr. Beyke was the principal author of the ERH section of the Engineering Manual for *In Situ* Thermal Remediation produced by the USACE.

3.6 Supplemental Personnel

Additional or supplemental field personnel will be required to perform site tasks including equipment monitoring and maintenance activities, collection of field data, groundwater sampling, and field analysis. Supplemental personnel will be under the direction of the Site Supervisor, the Safety and Health Manager, and the QC Manager. The staff will be of sufficient size to ensure adequate and safe completion of work and tasks involved in the fieldwork.

3.7 Subcontractor Personnel

Subcontractors will be employed or contracted for a variety of services during this project. Subcontracted firms will provide a limited amount of technical and construction assistance, drilling services, and transportation services for the disposal of the waste materials. Subcontractors will be responsible for following the required, specific components of the Work Plan, and in accordance with all state and federal regulations that apply to their specific tasks, including transportation and disposal. Landau will be responsible for overseeing the drilling subcontractors and ensuring their cooperation and adherence to the project specifications and state and federal regulations.

3.8 Organizational Changes

TRS will obtain Landau's acceptance before replacing a member of the project staff. Requests will include the names, qualifications, duties, and responsibilities of each proposed replacement.

3.9 Communication

Communication will be an important aspect of effective management and the QC process of on-site activities for this project. Communication between Landau, TRS personnel, and subcontracted firms will be coordinated with the PM and QC Manager.

Project information will be distributed to Landau using email, posted memorandums and announcements, daily site briefings, and weekly team status reports and meetings. Project communication will be accomplished during field activities via cell phones.

4.0 THREE-PHASE QUALITY CONTROL

CQC is the means by which the Contractor ensures that its work products and those of its subcontractors and suppliers comply with contract requirements. Controls must be adequate to cover operations and are keyed to the proposed operational sequence—pre-field work, fieldwork, and post-field work stages. QC procedures are presented in the following tables:

- Phase I: Pre-Field Work (preparatory) - Table 1
- Phase II: Field Work (initial) - Table 2
- Phase III: Post-Field Work (follow-up) - Table 3

Each of the work processes is identified in the tables along with the preparatory, initial and follow-up controls required for maintaining the project QC objectives.

The QC Manager, with the assistance and input of all team members, will follow these three-step procedures to maintain overall project management control and data quality objectives.

The tables follow the text portion of this document.

5.0 TESTING QUALITY CONTROL

TRS will perform the specified tests and system analyses to verify that control measures are adequate to provide a product, which conforms to the contract requirements. The SAP and Work Plan provide details for the specific tests that will be performed. As part of the documentation process, TRS will complete the following activities and record the associated data:

- Verify that instrument calibration data is sufficient when compared with standards. The specifications and procedures for instrument calibration are provided by the vendor and will be available at the site.
- Verify that recording forms are completed and the identification control number system, including the test documentation requirements, has been properly documented.
- Results of all project tests and calibrations will be filed by the project PM when tests are completed. Specification paragraph reference, location where tests were taken, and the sequential control number identifying the test will be documented.

6.0 COMPLETION INSPECTION

6.1 Punch-List Inspection

At the completion of work for a specific construction task, installation of a system component, or significant operation and maintenance task, the QC manager will conduct an inspection of the work and develop a "punch list" of items, which will be addressed or corrected to ensure the final product is consistent with approved work plans and contract specifications. The list of deficiencies will be presented to the PM to document the items and to determine a date specifying when the deficiencies will be corrected. The QC Manager will make a second follow-up inspection to verify and document that deficiencies have been corrected.

6.2 Final Acceptance Inspection

TRS QC Inspection personnel, Landau, and other TRS site management personnel will be in attendance at the final inspection for acceptance of final system completion or completion of significant treatment system components. An acceptance inspection will also be conducted to verify the satisfactory implementation of remedies to components or products not accepted during an initial inspection. TRS will notify Landau at least 15 days prior to conducting the final acceptance inspection. The notice will be provided and shall include TRS' assurance that all work performed for inspection shall in accordance with the contract specifications and will be completed by the date scheduled for the final acceptance inspection.

7.0 DOCUMENTATION

7.1 Electronic Reporting and Field Notes

The Contractor will maintain a weekly record of QC operations, activities, and tests performed in conjunction with this project. The documentation will also include the work of subcontractors and suppliers. Field notes may be submitted as part of the final report.

The PM will maintain a complete description of site activities, on-site personnel, inspections and the results of those inspections, progress status of tasks, tests and results, and other items to fully document the project field activities including:

- Areas of responsibility for TRS and subcontractor tasks.
- Status of system operations and equipment with hours worked, idle, or down for repair.

- Work performed daily, giving location, description and task personnel.
- Test completed, test results, and other control activities performed with results and references to specification requirements.
- Material received with bill of lading and receiving statement as to its acceptability, storage, and reference to the project specification or drawings that require use of the items.
- Submittals and deliverables reviewed, with contract reference, by whom, and any corrective actions taken.
- Documentation of safety briefings and evaluations of tasks being performed stating what was checked, results, and instructions or corrective actions.
- Instructions or directives given or received from Landau or subcontractors and discrepancies in plans and/or specifications.
- A verification statement of work or tasks completed and accepted.
- A description of subcontractors working on the project; the number of personnel working; weather conditions; and delays encountered. The records will cover both conforming and deficient features and will include a statement that equipment and materials incorporated in the work and workmanship comply with the contract.

TRS may elect to maintain logbooks for the separate project phases and specific tasks. These notations will be kept on-site and made available for Landau at any reasonable time

Table 1. Pre-Field Work - Contractor Quality Control Matrix

Feature of Work	Preparatory Controls	Initial Controls	Follow up Controls
Develop Work Plan	Verify receipt of Notice to Proceed (NTP). Review Contract and Scope of Work. Define Project Tasks Select Subcontractors and Vendors. Draft initial documents. Draft site maps and figures. Submit Submittal Register to Landau	Open job order number. Conduct job walk, if needed. Meet with Landau reps & end user client. Review assumptions to verify tasks. Verify qualifications and certifications. CQC Officer and peer review of documents. Review documents to verify accuracy and assumptions.	Set up accounting file. Verify tasks and assumptions. Negotiate changes to scope as needed. Obtain Landau certification if needed. Make revisions to documents as needed. Maintain records file.
Submit Draft Work Plan	Prepare final document and related submittal forms. Submit to Landau in quantity specified.	Verify document is in compliance with contract. Final CQC review.	Revise as necessary. Sign off on TRS review document. Maintain records file.
Revise Work Plan	Review comments on. Develop responses. Resubmit document with revisions.	Contact Landau reviewer, if necessary, to clarify comments. CQC review.	Revise document to address comments. Sign off on TRS review document. Maintain records file.
Pre Mobilization Activity	Assign work crews and staff. Notify vendors. Notify lab regarding sample submittal. Verify schedules and assignments.	Verify schedules. Establish accounting and billing procedures. Notify Landau regarding intent to begin fieldwork. Obtain necessary permits. Written/oral notice to crew & vendors.	Reassign crew if necessary. Establish estimated budgets. Follow up phone call to lab to expect sample receipt. Reassign or reschedule tasks as necessary.

Table 2. Field Work - Contractor Quality Control Matrix

Feature of Work	Preparatory Controls	Initial Controls	Follow up Controls
Site Set-up/ Orientation	Review relevant contract sections. Review Work Plan. Review Drawings. Instruct workers as to the level of effort and workmanship required. Establish CP and work zones. Establish sanitary facility. Document Activity.	Conduct initial site walk and construction support activities for site access. Survey site and stake out grids for treatment areas. Site orientation with pertinent personnel. Check all equipment or delivery status for equipment. Begin weekly reporting.	Maintain site controls and access points. Document all personnel on-site. Service sanitary facilities. Maintain scheduling and oversight of sub contractors. Report and correct deficiencies. Submit copy of weekly report(s).
Install electrodes and subsurface monitoring equipment	Review relevant contract sections. Determine appropriate installation points. Verify drillers schedule and tasks. Ensure base access documents completed and approved. Document Activity.	Conduct Safety and Health Briefings. Maintain QC during drilling activities. Complete installation in compliance with the project Work Plan. Record volumes and efforts of field activities. Document Activity.	Maintain security fencing around treatment area. Record task documentation in the Field Log. Submit copy of weekly report(s).
Operate, monitor, sample ERH system	Review relevant contract sections. Verify system has operational. Conduct hazard analysis. Obtain prior Landau approval for deviation from contract specifications. Document activity.	Use only certified materials for O&M operations. Use appropriate trained personnel for operations or maintenance. Document all operation times, periods of downtime, and maintenance procedures. Review field notes/CQC report(s).	Document all system activities. Report and correct deficiencies.

Feature of Work	Preparatory Controls	Initial Controls	Follow up Controls
Disposal of contaminant materials	Review relevant contract sections. Identify volumes of material for disposal. Schedule transport and disposal services. Verify legal load limits. Obtain copies of Bills of Lading, manifests, and LDR forms. Document Activity.	Conduct Safety and Health Briefings. Maintain QC during all field activities. Maintain vigilance over loading operations. Record volumes of load removed. Review Field Notes/CQC report.	Obtain disposal receipts identifying material and volume removed. Report and correct deficiencies. Submit copy of weekly report(s).

Table 3. Post-Field Work - Contractor Quality Control Matrix

Feature of Work	Preparatory Controls	Initial Controls	Follow up Controls
De-mobilize	Review Contract Requirements. Notify Landau personnel of demobe activities. Obtain COR approvals of work & approval to demobilize.	Obtain Landau approval to demobilize. Collect and remove supplies, equipment and project debris. Secure project site. Schedule Landau inspection of site. Secure access gates. Document all demobe activities.	Identify and correct deficiencies. Receive letter from Landau that demobe activities are accepted and completed.
Documentation	Review contract requirements. Review project file. Draft Field Report for Landau.	Conduct QC review of Data Quality. Verify project record file is complete (i.e. field notes, sample records, disposal records, transport documents, etc are present).	Obtain sign off(s) on QC review(s). Verify copies of records are included in Field Report. Identify and correct deficiencies.

APPENDIX F

ARARs

APPENDIX F
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The Model Toxics Control Act (MTCA), under WAC 173-340-710, requires that interim actions (IAs) comply with legally applicable state and federal laws and regulations, and those requirements determined to be relevant and appropriate (hereinafter "ARARs"). This section discusses the ARARs applicable or potentially applicable for the source control IA at Powder Mill Gulch (PMG). The definition of ARARs and associated concepts are discussed below.

"Applicable" requirements under MTCA are those cleanup standards, standards of control, and other human health and environmental protection requirements, criteria, or limitations adopted under state or federal law that specifically address a hazardous substance, cleanup action, location, or other circumstance at a site [WAC 173-340-710(3)].

"Relevant and appropriate" requirements include those cleanup standards, standards of control, and other human health and environmental requirements, criteria, or limitations established under state or federal law that, while not legally applicable to the hazardous substance, cleanup action, location, or other circumstance at a site, address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the particular site [WAC 173-340-710(4)]. The criteria to be used [WAC 173-340-710(4)] in determining whether a requirement is relevant and appropriate include:

- Whether the purpose underlying the requirement is similar to the purpose of the cleanup action
- Whether the media regulated or affected by the requirement is similar to the media contaminated or affected at the site
- Whether the hazardous substance regulated by the requirement is similar to the hazardous substance found at the site
- Whether the entities or interests affected or protected by the requirement are similar to the entities or interests affected by the site
- Whether the actions or activities regulated by the requirement are similar to the cleanup action contemplated at the site
- Whether any variance, waiver, or exemption to the requirements are available for the circumstances of the site
- Whether the type of place regulated is similar to the site
- Whether the type and size of structure or site regulated is similar to the type and size of structure or site affected by the release or contemplated by the cleanup action

- Whether any consideration of use or potential use of affected resources in the requirement is similar to the use or potential use of the resources affected by the site or contemplated cleanup action.

In accordance with WAC 173-340-710(9)(b), remedial actions conducted under an agreed order, including IAs, are exempt from the procedural requirements of certain state and local laws, including the Washington State Clean Air Act (Chapter 70.94 RCW), Washington State Solid Waste Management Act (Chapter 70.95 RCW), Washington State Hazardous Waste Management Act (Chapter 70.105 RCW), Washington State Construction Projects in Water Act (Chapter 75.20 RCW, recodified at Chapter 77.55 RCW), Washington State Water Pollution Control (Chapter 90.48 RCW), and Washington State Shoreline Management Act (Chapter 90.58 RCW), as well as any laws requiring or authorizing local government permits or approvals for the action. The IA must still comply with the substantive requirements of the laws in accordance with WAC 173-340-710(9)(c). It is part of the Washington State Department of Ecology's (Ecology) role under an agreed order to ensure compliance with the substantive requirements, and to provide an opportunity for comment by the public, state agencies, and local governments [WAC 173-340-170(9)(d)]. In addition, the IA is not exempt from fully complying with federal regulations and obtaining permits from federal agencies, such as a Clean Water Act Section 404 permit.

CHEMICAL-SPECIFIC ARARS

Chemical-specific ARARs generally set risk-based concentration limits for specific chemicals within environmental media. The chemical-specific ARAR values may identify an acceptable amount or concentration of a hazardous substance that may be found in or discharged to the environment.

This IA is focused on trichloroethene (TCE) in groundwater and surface water at PMG. Chemical-specific ARARs for groundwater include cleanup levels established under MTCA (WAC 173-340-720); maximum contaminant levels (MCLs) established under the Safe Drinking Water Act, published in 40 CFR 141; and maximum contaminant levels established by the state board of health and published in WAC Chapter 246-290. Chemical-specific ARARs for surface water include cleanup levels established under MTCA (WAC 173-340-730); water quality criteria published under Section 304 of the Clean Water Act; and concentrations published in the National Toxics Rule, 40 CFR Part 131. Screening levels for TCE, described in section 1.5 of the RI (Landau Associates – In Preparation), are 0.11 μg/L for groundwater and 1.5 μg/L for surface water. Cleanup levels for the final corrective action will be established through a cooperative effort between Ecology and Boeing during the feasibility study (FS) and cleanup action plan (CAP) process, subsequent to performance of this IA. The objective of the IA is to reduce the remediation timeframe for the dissolved-phase groundwater plume through destruction of TCE mass in the source zone. It is unlikely the IA will reduce source zone groundwater concentrations to screening levels or cleanup levels in the short term; however, it is expected that the IA will reduce concentrations to levels appropriate for implementation of MNA and achievement of remedial action objectives (RAOs) for downgradient plumes.

LOCATION-SPECIFIC ARARS

Location-specific ARARs are those requirements that relate to the geographical position or physical condition of the site or its immediate environment. These requirements may limit the type of remedial action that can be implemented, or may impose additional constraints on some remedial alternatives. Location-specific ARARs that are potentially applicable to the IA are briefly described below.

SPECIAL STATUS SPECIES

Endangered Species Act (ESA) 16 USC 1531-1543, 50 CFR Parts 17 and 402

The objective of the ESA is to ensure that activities authorized by the state or federal government do not jeopardize the continued existence of endangered or threatened species or the ecosystems they depend upon. The ESA would be potentially applicable to the IA if threatened or endangered species were present in the work area; however, no threatened or endangered species are known to be present based upon a site reconnaissance, Washington Department of Fish and Wildlife priority species maps, and a U.S. Army Corps of Engineers review (URS 2006).

Native American Concerns and Cultural Resources Protection

Native American Graves Protection and Repatriation Act (NAGPRA) Regulations, 25 USC 3001 et. seq; 43 CFR Part 10.1, 10.4 and 10.5

This act protects Native American burial sites and funerary objects. If Native American graves are discovered within the area where the IA is conducted, the U.S. Department of Interior and the Indian tribe with ownership must be notified of the inadvertent discovery and the activity must cease until a reasonable effort is taken to protect the discovered items. Although NAGPRA regulations are potentially applicable to this IA, it is unlikely that Native American burial sites or funerary objects will be encountered during the IA because the work area was previously disturbed during construction of the existing stormwater detention basin and no additional excavation is planned.

National Historic Preservation Act (NHPA), 16 USC 470; 36 CFR Parts 60, 65, and 800

The NHPA requires federal agencies to assess the impact of proposed actions on historic or culturally important sites, structures, or objects within the site of the proposed projects. It further requires federal agencies to assess all sites, buildings, and objects on the site to determine if any qualify for inclusion in the National Register of Historic Places (NRHP) or as a National Historic Landmark. The NHPA is not applicable because the IA will be conducted within the existing stormwater detention basin and no additional area will be disturbed.

Archaeological and Historic Preservation Act (AHPA), 16 USC 469

This act establishes procedures to provide for the preservation of historical and archeological data that might be destroyed through alteration of terrain as a result of a federally licensed activity or program. If historic or archaeological artifacts are present in the area where the remedial activity will occur, the remedial activity must be designed to minimize adverse effects on the artifacts. Although the AHPA is potentially applicable, no historic or archeological data are likely to be present in the IA work area because all work will be done within the existing stormwater detention basin.

Local Requirements

The Boeing property, including the IA area, is located within the city limits of the City of Everett. Consequently, City of Everett ordinances are potentially applicable to the interim action. A State Environmental Policy Act (SEPA) checklist has been submitted and this draft IA work plan will be submitted to the City of Everett for their review. The draft and final designs will also be submitted to the City for their review.

Snohomish County Shoreline Management Program, RCW 90.58; WAC 173-27-060, Chapter 30.44 Snohomish County Code and Critical Areas Ordinance (CAO), Chapter 30.62 SCC

The project site is within the city limits of the City of Everett; therefore, Snohomish County regulations are superseded by City regulations.

Environmentally Sensitive Areas Regulations, Title 19.37 Everett Municipal Code (EMC), Chapter 36.70A RCW

Development in critical areas is regulated under the Washington State Growth Management Act (Chapter 36.70A RCW), as implemented through ordinances developed by local jurisdictions. In 1995 the Growth Management Act was amended to require counties and cities to include the best available science in developing policies and development regulations to protect the functions and values of critical areas. All counties and cities in the state are required to review, evaluate, and, if necessary, revise their critical areas ordinances according to a schedule established by the state Legislature and approved by the Governor.

The City of Everett's critical areas ordinances are found at Title 19.37 EMC. Critical areas include geologically hazardous areas, wetlands, and streams. Any alteration or development in critical areas must be evaluated by the City for potential impacts. The EMC provisions require the submittal of "studies which describe the environmental conditions of the site" submitted by qualified experts [Title 37.070(B) EMC]. The City's practice is to require an environmental checklist under the SEPA (Chapter 43.21C RCW) for proposed development in critical areas. Information in the checklist is used to evaluate the potential effects of the proposed action. A mitigation plan is required in cases of permanent alteration of critical areas. This requirement is potentially applicable. To meet the requirements of the critical areas ordinance, a SEPA checklist has been submitted and this draft IA work plan will be submitted to the City of Everett for their review. The draft and final designs will also be submitted to the City for their review.

Washington State Shoreline Management Act and City of Everett Shoreline Management Program, RCW 90.58; WAC 173-27-060, Title 19.30A EMC

The Shoreline Management Act is a state program administered in partnership with local jurisdictions. Local implementation programs are approved by Ecology, after which the local jurisdiction is the lead agency for permitting and other regulatory activity. Under the EMC, activities within the Watershed Resource Management Zone require a shoreline permit. The Shoreline Management Program applies to shorelines of the state. "Shorelines" are lakes, including reservoirs, of 20 acres or greater; streams with a mean annual flow of 20 cubic feet per second (cfs) or greater; marine waters; plus an area landward for 200 ft measured on a horizontal plane from the ordinary high water mark; and all associated marshes, bogs, swamps, and river deltas. Floodplains and floodways incorporated into local shoreline master programs are also included. Although these requirements are potentially applicable, because Powder Mill Creek (PMC) generally does not have a flow of 20 cfs, City officials stated informally to URS during review of the SEPA checklist and IA work plan for the PMC sediment removal IA that activities within PMC most likely will not be regulated as part of this program. A SEPA checklist has been submitted and this draft IA work plan will be submitted to the City of Everett for their review. The draft and final designs will also be submitted to the City for their review.

City of Everett Grading Code, Title 18.28.200 EMC

Title 18.28 EMC, Land Division Evaluation Criteria and Development Standards, requires a grading plan to be submitted to the city engineer "before any site modification where existing natural features would be disturbed or removed"[18.28.200(A)]. The EMC establishes minimum standards for clearing and grading, generally based on following "sound engineering techniques." The EMC states, in relationship to environmentally sensitive areas, that "Clearing and grading limits shall be established so as to not impact environmentally sensitive areas, the required buffers, and adjacent properties," [18.28.200(E)(4)] and that "on projects that have environmentally sensitive features and in critical drainage areas, clearing and grading and other significant earth work may be limited to a specific time period as determined by the city" [18.28.200(F)]. This requirement is potentially applicable. No grading is planned for the IA activities in the source area; however, a small quantity of crushed rock will be added to the existing rock/asphalt pad along the western edge of the detention pond to provide a pad for the remediation equipment. A SEPA checklist has been submitted and this draft IA work plan will be submitted to the City of Everett for their review. The draft and final designs will also be submitted to the City for their review.

ACTION-SPECIFIC ARARs

Action-specific ARARs are usually technology- or activity-based requirements or restrictions on actions taken with respect to hazardous substances. These requirements are triggered by the particular remedial alternative and set performance, design, or other standards that will be used to implement the proposed remedial action. These requirements are triggered by the remedial or interim actions selected. The action-specific requirements do not in themselves determine the selected remedial or interim action alternative; rather, they indicate how, or to what level, a selected alternative must be achieved.

Discharge to Surface Water

Clean Water Act's (CWA) Pretreatment Regulations (40 CFR Part 503.5, City of Everett Code Title 14 Water and Sewers)

These regulations and city ordinances are potentially applicable if construction dewatering water or condensate from the IA treatment system is discharged to the City's publicly owned treatment works [POTW; including through Boeing's wastewater treatment plant (WWTP)], which discharges to the Everett POTW). The federal regulations and city ordinances limit pollutants in wastewater discharges to sanitary sewer systems to protect POTWs from accepting wastewater that would damage their system or cause them to exceed their permit discharge limits. Discharged water will be pretreated, if necessary, to meet the POTW discharge standards.

Stormwater Permit Program (33 USC 1342, RCW 90.48.260, 40 CFR 122.26; Chapter 173-220 WAC)

The Federal CWA, as delegated to Ecology under RCW 90.48.260, requires that a general stormwater permit be obtained for stormwater discharges associated with construction activities disturbing over 1 acre. Although the substantive provisions of the Washington State General Stormwater Permit for Construction Activities are potentially applicable to the IA if more than 1 acre is disturbed during construction activities and stormwater runoff is discharged to waters of the state, it is expected that the IA construction will disturb less than 1 acre.

State Environmental Policy Act, RCW 43.21.036, WAC 197-11-250 through 268

SEPA is potentially applicable. Under the SEPA rules, MTCA and SEPA processes are to be combined to reduce duplication and improve public participation (WAC 97-11-250). Ecology has determined that they will act as the lead agency for implementing the substantive requirements of SEPA as described in WAC 197-11-253. A SEPA checklist has been completed for the IA. The working assumption is that Ecology will determine that the IA will not have a probable significant adverse environmental impact and, therefore, a determination of nonsignificance (DNS) will be issued. Under WAC 197-11-268, for MTCA interim actions conducted under WAC 173-340-430 that will not have a probable significant adverse impact and for which a DNS is issued, the public notice of the interim action will be combined with the comment period on the DNS.

Discharge to Air

Washington Clean Air Act and Implementing Regulations (Chapter 70.94 RCW, WAC 173-400-040(8); WAC 173-460); Puget Sound Clean Air Agency (PSCAA) Regulation I, Section 9.15

WAC 173-400-040(8) and PSCAA Regulation I, Section 9.15 requires owners and operators of fugitive dust source to take reasonable precautions to prevent fugitive dust from becoming airborne and to maintain and operate the source to minimize emissions. These requirements are potentially applicable to controlling fugitive dust emissions during implementation of the IA.

Washington Clean Air Act and Implementing Regulations (Chapter 70.94 RCW, Chapter 173-400 WAC; Chapter 173-460 WAC); Federal Clean Air Act, National Emissions Standards for Hazardous Air Pollutants (40 CFR Parts 61 and 63), and Puget Sound Clean Air Agency (PSCAA) Regulation I require air permits for sources depending on the source type and the type and amount of air contaminants released. These permitting requirements are potentially applicable for discharges from the IA treatment system. However, based on conservative estimates, the quantity of hazardous air pollutants/toxic air contaminants that will be removed during the remediation activity is below that which requires permitting.

Hazardous and Solid Waste Management

Resource Conservation and Recovery Act (RCRA) and Washington Hazardous Waste Management Act and Dangerous Waste Regulations (42 USC 6901 et. seq., 40 CFR 260, 261, 262, 263, and 268, Chapter 70.105 RCW, Chapter 173-303 WAC)

The Washington State Dangerous Waste requirements and federal RCRA requirements for non-authorized programs are potentially applicable to the IA if the sediment or soils are determined to be hazardous and/or state-only dangerous waste. These regulations identify the requirements for characterization, management, and disposal of waste and contaminated media (i.e., soil and sediment). For onsite management, these requirements are a potential ARAR. For offsite activities, the requirements of the federal RCRA regulations and Washington State Dangerous waste regulations must be fully complied with. Waste and contaminated media must be properly characterized to determine if it is a hazardous and/or dangerous waste under WAC 173-303-070 through 173-303-100 If the wastes or contaminated media destined for offsite disposal are determined to be a hazardous and/or dangerous waste, then the substantive requirements for characterization and management under Chapter 173-303 WAC would need to be met for the onsite hazardous and/or dangerous waste. The offsite transportation and disposal of these wastes would need to comply fully with the RCRA and dangerous waste regulations. Disposition of waste will occur at facilities that are licensed and permitted to accept the specific hazardous waste material. Soil cuttings from drilling activities and water generated during groundwater monitoring activities will be tested prior to disposal to determine if they contain hazardous and/or dangerous waste.

Washington Solid Waste Management Act and Solid Waste Management Handling Standards Regulations (Chapter 70.95 RCW, Chapter 173-350 WAC)

The solid waste requirements are potentially applicable to the offsite disposal of solid nonhazardous wastes and contaminated media that may be generated as part of the IA. For offsite disposal activities, these requirements must be fully complied with.

Water Resources

Water Well Construction (Chapter 18.104 RCW), Minimum Standards for Construction and Maintenance of Wells (Chapter 173-162 WAC), Regulation and Licensing of Well Contractors and Operators (Chapter 173-162 WAC)

This law and the implementing regulations control the installation and maintenance of wells, including monitoring wells. These requirements are applicable to the IA for the installation of monitoring wells and electrode wells installed as part of the IA. Monitoring wells will be designed and installed in accordance with the regulation and a Start Card will be filed with Ecology for well installation activities.

Health and Safety

Washington Industrial Safety and Health Act (Chapter 49.17 RCW) and the federal Occupational Safety and Health Act (29 CFR 1910, 1926)

These regulations include requirements that workers are to be protected from exposure to contaminants. These requirements are potentially applicable. A health and safety plan will be prepared for and complied with during IA activities.

REFERENCE

URS. 2006. State Environmental Policy Act (SEPA), chapter 43.21C RCW, Checklist - *Powder Mill Creek Interim Cleanup Action*. March.

APPENDIX G

System Operations and Maintenance Plan

Operation and Maintenance Plan

In Situ Thermal Remediation
(Electrical Resistance Heating)

Powder Mill Gulch Site
Everett, Washington

THERMAL REMEDIATION services inc.

Prepared by

Thermal Remediation Services, Inc.
2325 Hudson Street
Longview, Washington 98632

Table of Contents

Abbreviations and Acronyms

ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CM	Contract Manager
COR	Contracting Officer Representative
CQC	Contractor Quality Control
CQCP	Contractor Quality Control Plan
DNAPL	Dense Nonaqueous Phase Liquid
ERH	Electrical Resistance Heating
ESHM	Environmental Safety and Health Manager
FSP	Field Sampling Plan
GAC	Granular Activated Carbon
NAPL	Nonaqueous Phase Liquid
OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethane
PCU	Power Control Unit
PID	Photoionization Detector
PM	Project Manager
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
SAP	Sampling and Analysis Plan
SSHO	Site Safety and Health Officer
TCE	Trichloroethene
Landau	Landau Associates, Inc.
TRS	Thermal Remediation Services
USEPA	U.S. Environmental Protection Agency
WMP	Waste Management Plan

1. Introduction

This document focuses on the responsibilities of TRS and Landau in the operations and maintenance of the ERH system. General Responsibilities are listed in the scope of work list below.

The TRS scope of work is summarized below:

- Surround the equipment compound with security fencing. TRS assumes that a standard equipment compound measuring approximately 80 by 40 feet will be sufficient for the needs of this project.
- Provide oversight during installation of the electrodes and co-located VR wells, the groundwater monitoring wells and co-located TMPs, and the vacuum monitoring wells. TRS personnel can help to supervise the drill rig(s) – this may be particularly helpful if two drill rigs are used.
- Provide initial oversight during the first week of the installation of piping. Following the first week of installation, TRS is likely to have personnel on site positioning equipment and connecting cables and sensors – these on site personnel will be available for piping questions and assistance.
- Provide electrical connections between all ERH system components, provide ERH system interlocks and alarms, and perform system start-up.
- Perform ERH system operations and monitoring except for the monitoring elements described below in Landau's scope of work.
- During operations, monitor system performance through the measurement of subsurface temperature, pressure and airflow, as well as energy input and condensate production.
- Provide weekly operating reports.
- Provide a cooling device for hot groundwater sampling.
- Demobilize all above grade system components placed by TRS.

<u>The Landau scope of work is summarized below:</u>

- Supply of electrical power to the TRS Power Control Unit (PCU), which will be staged in the equipment compound.

- Hire and directly supervise a drilling contractor to complete all subsurface installations per the design specifications provided by TRS, including:

  - Electrode and co-located VR wells.

  - Groundwater monitoring wells and co-located TMPs.

  - Vacuum monitoring wells.

  - Landau's drilling contractor will provide all standard well construction materials (sand, grout, and bentonite).

  - Landau will be responsible for all materials associated with the groundwater monitoring wells, including sampling pumps.

  - Landau's drilling contractor will seal all wells and provide surface completions as necessary.

  - Landau's drilling contractor will be responsible for installing and anchoring the groundwater monitoring well risers.

- Provide materials, labor and direct supervision to complete the following tasks:

  - Piping from the electrode/VR wells

  - Risers for access of the groundwater monitoring wells.

  - Construct the manifold and install all valves, sampling ports and instrumentation for the VR system up to the blower provided by TRS.

  - Construct the manifold and install all valves, sampling ports, and instrumentation for the vacuum monitoring system.

  - Bracing and anchoring for the submerged components provided by Landau.

  - Run electrical cables and piping from the basin across the road to the equipment compound.

  - Pressure testing of all piping that will be submerged during system operations.

- Provide a potable water source capable of 5-7 gallons per minute. A garden hose will be sufficient.

- Handling, storage, characterization and disposal of all waste generated during drilling and system installation.

- Weekly system monitoring, as needed, including monitoring of the vapor and the condensate treatment systems.

- Collecting and analyzing air (vapor stream) and water (condensate) samples for permit approval and compliance, for measurement of remediation progress, to determine need for liquid and vapor phase GAC replacement, and for VOC mass removal calculations.

- Liquid and vapor phase granular activated carbon (GAC) vessels. Replacement and disposal of spent GAC from the vapor and the condensate treatment systems.

- Confirmational groundwater sampling and analysis to demonstrate achievement of performance criteria. Confirmational sampling is anticipated to occur 4 to 5 times during treatment.

2. Project Schedule

Following contract award and notice to proceed, TRS will provide a detailed work schedule indicating the sequencing and schedule of each step of the remediation process. ERH system installation activities will commence July 1, 2006 and operations will begin no later than September 30, 2006. Remediation is to be completed, as documented by groundwater confirmation sampling results, by December 31, 2007.

3. Subsurface Installation

TRS will mark all drilling locations. Boeing and/or Landau will contract directly with and manage the drilling company. TRS will coordinate with Landau and the driller for the installation of the electrodes and co-located VR wells, the groundwater monitoring wells (MW) and co-located TMPs, and the vacuum monitoring wells. TRS will provide all specialty materials for the construction of the electrodes and co-located VR wells, groundwater MW and the co-located TMPs and will transport them to the Site or to the warehouse of Boeing/Landau's driller. The driller will offload the TRS-supplied materials regardless of where they are delivered.

The driller will provide sand and Portland cement grout backfill for the upper portion of each electrode borehole as shown in the design drawings. TRS will provide on-site supervision during the installation of these subsurface components, but will not produce boring logs.

As a means of monitoring the ERH process, TRS's equipment will be able to provide continuous thermal data collection within the subsurface. Temperature data will be automatically recorded at least once per day from ten TMPs co-located with the MWs. Each TMP will have one temperature sensor per five vertical feet of treatment zone.

4. Surface Installation

TRS will be responsible for the placement of the power control unit, blower, cooling tower, and condenser. This equipment will be decontaminated and fully serviced before arriving on-site. TRS will wire in the interlock system for equipment operations. TRS will be present for piping installation , and will provide oversight for the surface installation tasks performed by Landau and its contractors.

5. Waste Management

Boeing and/or Landau are responsible for handling, storage, characterization and disposal of all waste generated during drilling and system installation. TRS estimates that approximately 85 tons of drill cuttings requiring disposal will be generated during system installation.

During application of the ERH process, steam will be collected from the subsurface and removed from the vapor stream using a steam condenser unit. The condensate will be used as a makeup water source to the cooling system of the condenser, where it will be evaporated over time. The condensate will also be used as a source of makeup water to the electrodes for use in maintaining moisture content at the electrode to soil interface. Any water re-injected to the subsurface will meet the requirements of all applicable permits. The added water will ensure that the soil immediately adjacent to the electrodes remains moist and electrically conductive. Condensate will be treated with liquid phase GAC and recycled as cooling water resulting in little or no discharge of condensate water to the sewer.

Recovered vapors will be treated by vapor phase GAC. Based on the estimated amount of VOCs in the remediation area, TRS anticipates that approximately 6,000 to 13,000 pounds of GAC will be required during the remediation effort depending on the scenario selected. Boeing and/or Landau are responsible for vapor phase GAC vessels, the initial load of GAC and replacement and disposal of used GAC. From our experience at other ERH sites, TRS estimates that 250 pounds or less of liquid phase GAC will be adequate for the remediation effort. Boeing and/or Landau are responsible for liquid phase GAC vessels, the initial load of GAC and replacement and disposal of used GAC.

TRS will be responsible for collection and disposal of garbage, personal protective equipment, plastic sheeting and unused materials that it generates during the ERH remediation.

6. ERH Treatment

Once installation is complete, TRS will perform system startup and testing. This process typically takes about one week, however for project scheduling purposes, TRS recommends allocating two weeks. TRS will also confirm the proper operation of its interlock systems and remote monitoring and control. Pressure tests of the VR piping system will be performed before power is applied to the electrodes.

The vapor recovery system has been designed to produce a minimum vacuum of 0.1 inch of water at all points located 10 feet beyond the remediation area. Vacuum will be confirmed with four vadose zone monitoring points located outside of the remediation area. In the unlikely event that additional blowers or other vapor recovery modification are required, a changed condition will result.

During operations, TRS will monitor the system remotely, via telephone service, and will provide weekly updates to Landau via electronic letter reports. These reports will describe the general operations of the ERH system; work performed during the previous week, and anticipated upcoming work. The reports will also contain data on the subsurface temperature profile, power used by the entire remediation system and energy input to the subsurface.

TRS will provide weekly site visits for visual inspection and maintenance of the ERH components of the system. Near the end of the remediation, TRS might reduce the site visit frequency to once every two weeks. Additional trips will be made as necessary to ensure the ERH system is functioning efficiently and effectively.

TRS will be responsible for the security of our equipment and materials throughout the duration of the work.

Table 1 describes the scheduled Operations & Monitoring items that will be required during the ERH remediation.

Table 1. System Operations and Monitoring Schedule

Operation/Maintenance Item	Performance Schedule	Performed By
Subsurface Temperatures	Daily	TRS
ERH Voltage, Current, and Power	Daily	TRS
Energy Input	Daily	TRS
Vapor Stream VOC Sample &Analysis	Weekly/Twice per Month	Landau
Condensate VOC Sample &Analysis	Twice per Month/Weekly	Landau
Liquid GAC VOC Analysis	Twice per Month/Weekly	Landau
Vapor GAC VOC Analysis	Twice per Month/Weekly	Landau
Applied Vacuum	Twice per Month/During Vapor Sampling	TRS/Landau
Total VR System Airflow	Twice per Month/During Vapor Sampling	TRS/Landau
Individual Electrode Currents	Twice per Month/per site visit	TRS
ERH Equipment Inspection	Twice per Month/per site visit	TRS
Blower Greasing/Oil Change	500 operating hours	TRS
Filter/Strainer Clean and Inspect	Twice per Month/per site visit	TRS/Landau

7. Demobilization

Landau will be responsible for confirmation sampling to decide when TRS has met contract specifications. Upon satisfactory completion of ERH remediation, TRS will decontaminate all equipment, and remove all components installed by TRS. Landau will leave the VR piping in place for use in possible electron donor injection.